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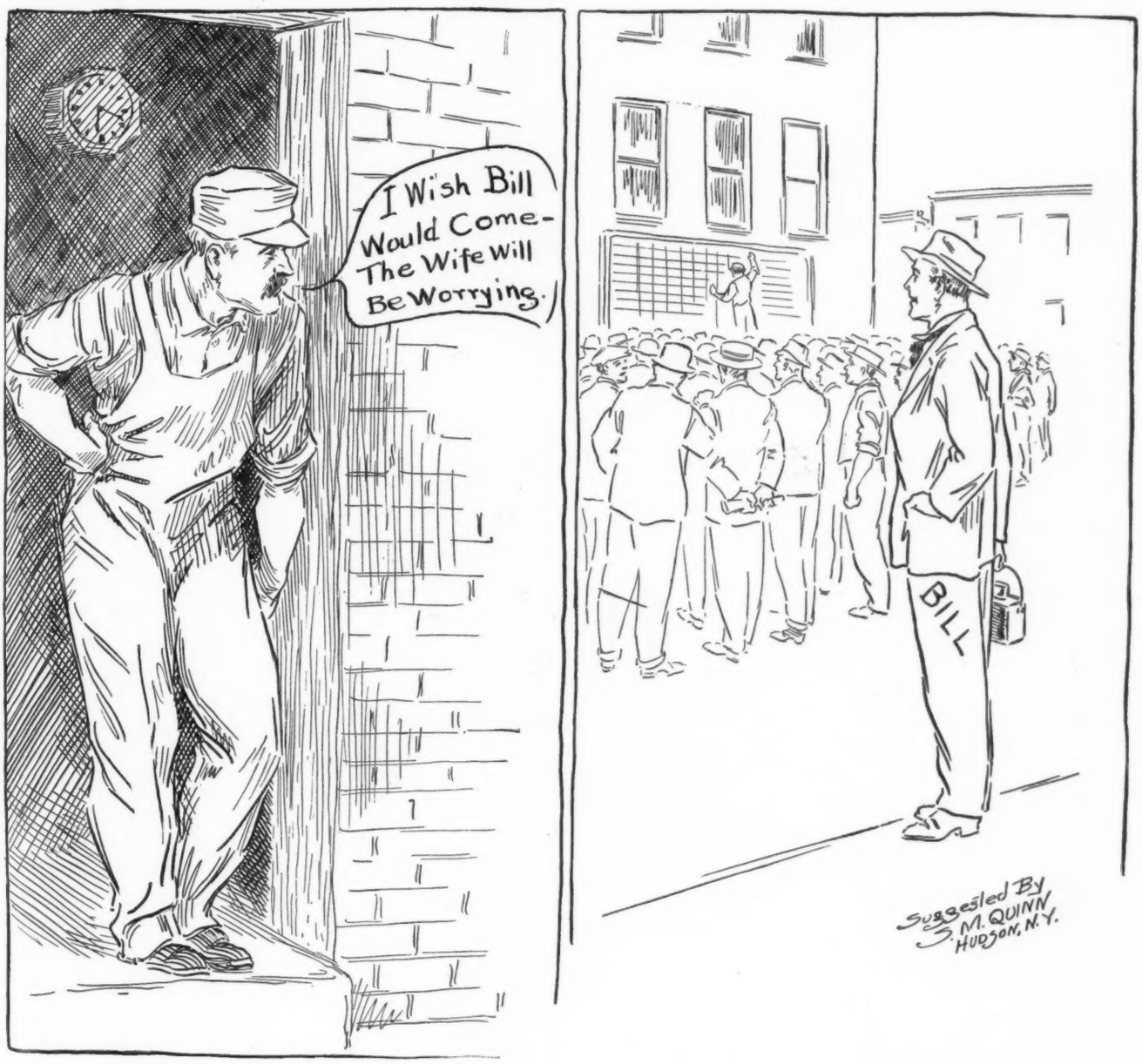

THE TARDY RELIEF

New York City's Power Problem

By A. D. Blake

SYNOPSIS—The group of city buildings adjacent to the Hall of Records affords an excellent opportunity for a central plant for heat, light and power. Some of these buildings are already on service from the Hall of Records plant; whether the rest of the available load will be taken over will depend largely on the outcome of a year's test now being carried on at this plant.

The long-controverted question as to whether New York City can more economically operate its own steam plants or purchase electrical energy and perhaps steam from outside sources is being carefully investigated through a test now being conducted on the plant at the Hall of Records at Chambers and Center Streets.

Tests extending over periods of several days or even weeks have not been uncommon in the past, but this, we believe, is the first instance of a complete plant test extending over a whole year and thus making available complete operating data for all seasons. Aside from arriving at the cost of producing electric energy, and its ultimate importance to the city, the test will go far toward showing what proportion of the total cost should be credited to exhaust-steam heating, hydraulic elevators, and various auxiliaries, conclusions about which have heretofore been largely a matter of conjecture.

Fig. 1. Hall of Records

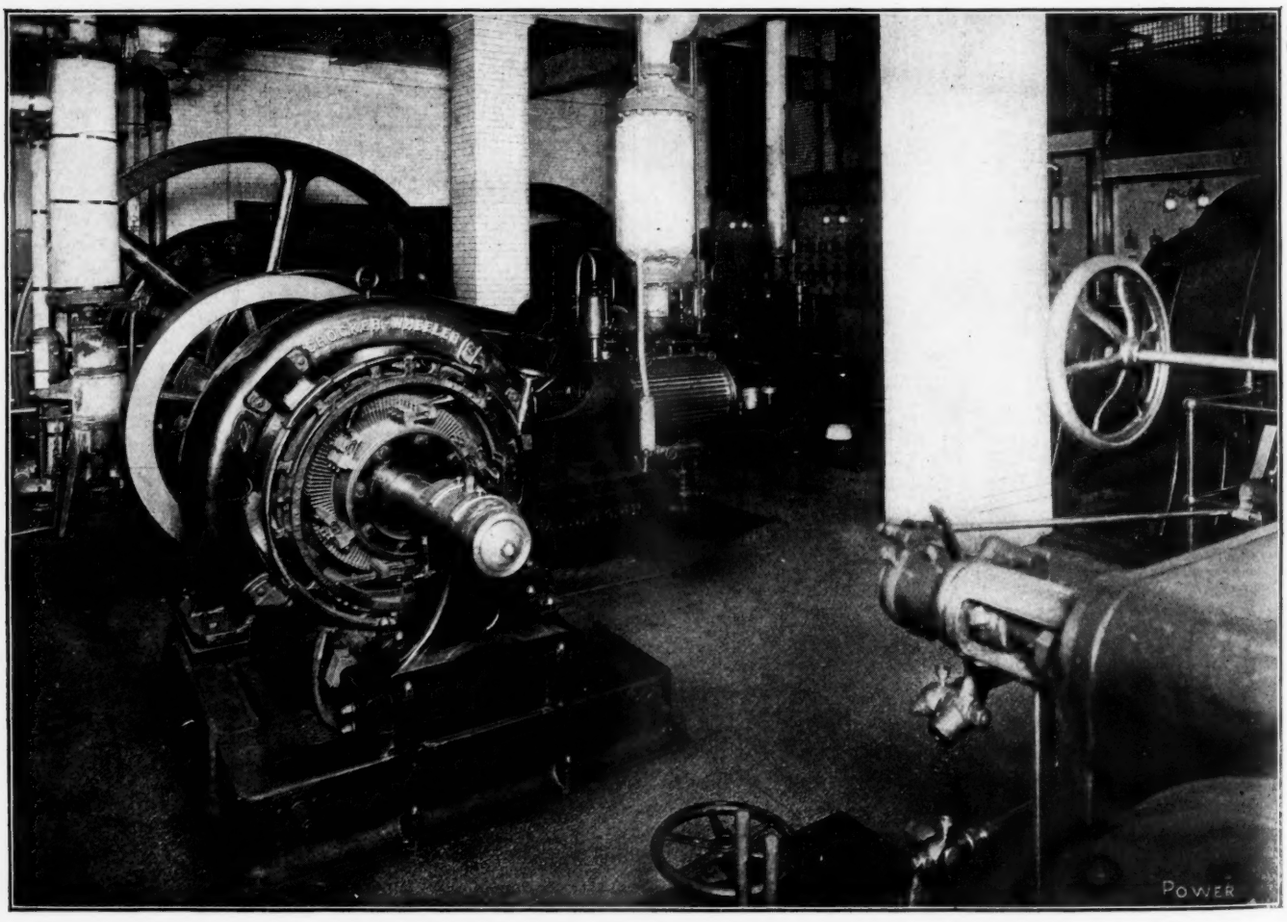

Fig. 2. Engine Room of Hall of Records

Reverting to the conditions leading up to the present test, a well equipped plant had been installed at the new Police Headquarters, but never operated, and other city plants, notably that at the Tombs prison, had been shut down about three years ago and Edison service substituted. These instances led to an investigation by the Bureau of Municipal Research, which, after compiling considerable data upon the operations of plants in the city, submitted an extensive report, which was favorable to the city-operated plant. This report, however, was open to attack, as it contained certain assumptions, which, in the absence of actual data, could not be satisfactorily substantiated.

To settle the question, it was finally decided to conduct a year's test on the plant of the Hall of Records under the general direction of the Bureau of Municipal Research, the New York Edison Co. and the city defraying the expenses. A board of six advisory engineers were selected, Professors R. C. Carpenter and C. E. Lucke representing the Bureau of Municipal Research, Messrs. R. P. Bolton and E. F. Tweedy the New York Edison Co., and Messrs. E. P. Goodrich and G. F. Sever the city. These selected Professor Diederichs, of Cornell University to conduct the test; he choosing his own observers from among Cornell students. The test was started Dec. 16, 1912, and the plant is being operated by the regular city employees, of whom John J. Daly is the chief engineer. Mr. L. R. Bates, mechanical engineer for the Department of Public Buildings, has general supervision over the operation.

The plant was installed in 1904 and the generators have a rated capacity of 450 kw. The equipment consists of five hand-fired B. & W. boilers, having a total capacity of approximately 1100 hp.; two 18x42-in. and one 16x36-in. Brown Corliss engines, direct-connected, respectively, to 150- and 100-kw., 120-volt, direct-current generators. In addition to these there is a 12x13-in. Watertown engine, driving a 50-kw. dynamo. All are noncondensing and exhaust to the heating system during the heating season. In the summer months, part of the exhaust is used in the 10-ton absorption-type refrigerating machine, which is used for cooling the drinking water.

There are six hydraulic elevators for passenger service, four book lifts and one sidewalk ash lift. The book lifts, however, are not used. This service is handled by three 16 and 25x12x15-in. compound-piston pumps and one 9x4x10-in. ram for safe lifting. This pumping plant also serves two hydraulic passenger elevators in the City Court Building.

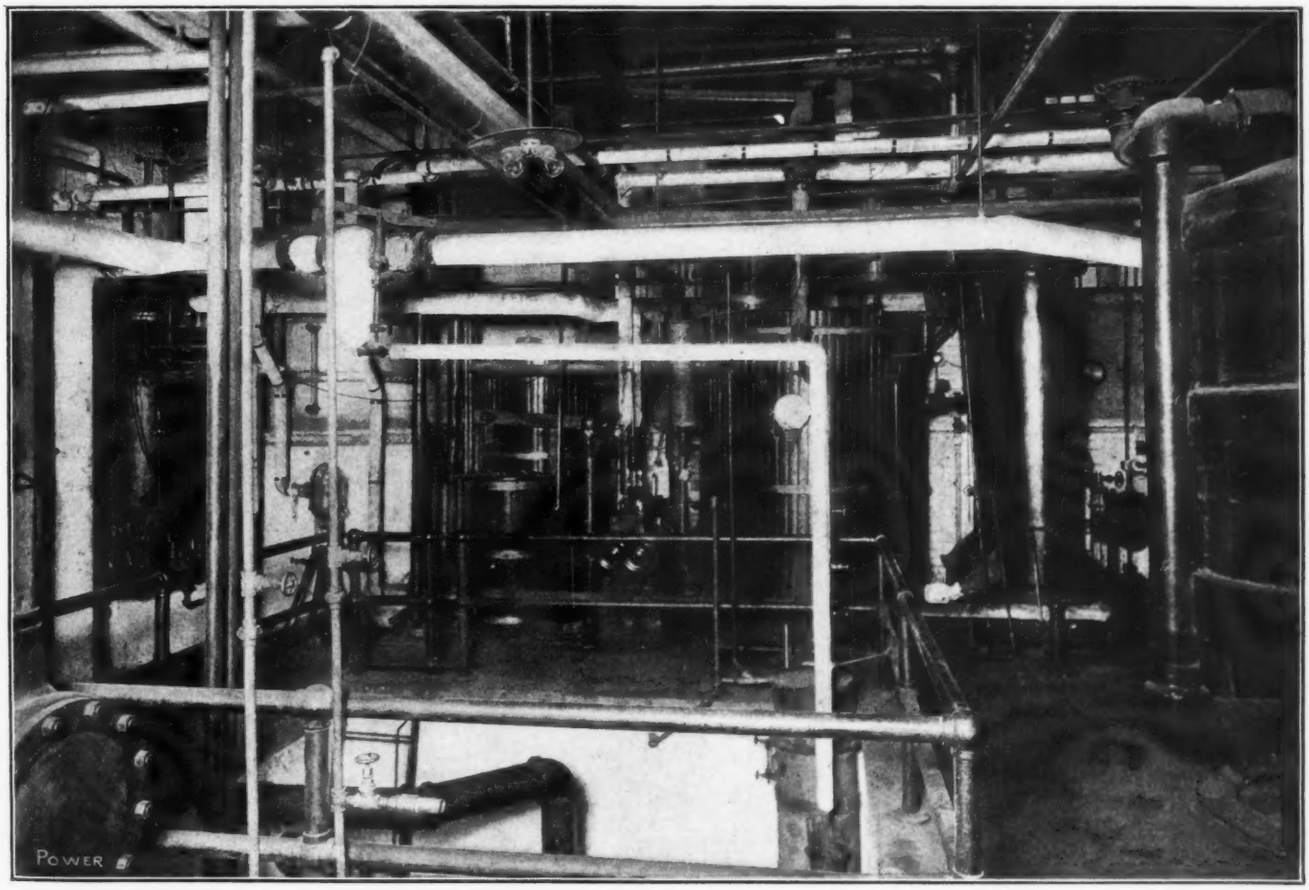

FIG. 3. REFRIGERATING MACHINE

A 57-cell, 1000-amp.-hr. storage battery is provided for night service during the summer months. In the heating season the 50-kw. generating unit is operated at night as the exhaust steam is utilized in the heating system.

In the present test water, steam and electric meters have been placed on all lines and circuits, within the building, as well as those supplying outside service, so that each part of the plant may be charged with its proper share of the load. Readings are taken every hour

and all classes of meters are calibrated at stated intervals.

Recording thermometers are placed on the feed-water lines and the cooling water returns, and there are indicating thermometers on all water-meter lines.

Two different types of CO_2 recorders are provided, one as a check upon the other, and there is also a smoke recorder installed in the boiler room, where it may be seen by the firemen at all times. All coal and ash are carefully weighed by the observers and the evaporation is posted from day to day on the blackboard in the fire-room, so that the firemen may know just what they are doing; this also has had the effect of stimulating competition among the firemen.

The plant is now being operated very satisfactorily with 15 men, including the chief, which is six less than in 1911, when conditions were somewhat different. Moreover, the same service is being performed with one less boiler, two being used in summer and three in winter. In line with the policy of the present administration, many economies have been effected, such as the use of exhaust steam in the refrigerating system, where live steam was formerly used, and the installation of a motor-driven air-compressor for the ejectors in place of the more uneconomical steam compressors previously used. Moreover, the heating and ventilating fans in the County Court House were changed from engine drive to motor drive, since with the engine drive it was necessary to use high-pressure steam from the New York Steam Co.

Exact figures as to operating costs will not be available until after the test has been completed. The overhead and fixed charges will be determined separately by the advisory board of engineers and will be added to the operating costs after the test has been completed.

The group of city buildings around the Hall of Records affords a splendid opportunity for a block system of steam and electric supply. Prior to the summer of 1911, the City Hall, the County Court House and the City Court House were supplied with steam from the mains of the New York Steam Co. and with electricity from the New York Edison Co. At that time, however, these buildings were connected with the Hall of Records by underground piping and were supplied with steam, hot and cold water, and, in the case of the City Court House, with water for elevator operation. This, according to the report of Borough President McAneny, resulted in a saving of $18,000 in fuel and labor the first year alone.

The following summer, cables were installed in the ducts provided under Chambers Street and the Hall of Records supplied electrical energy to the group of buildings in City Hall Park.

Even with this additional load the electrical plant is considerably underloaded, one unit being able to handle the load for the greater part of the time, and after 4 p. m. the lighting load falls off very rapidly. Obviously, anything that would tend to increase the night load and thus raise the load factor, would be extremely desirable. Such an opportunity appears in the lighting service on the Brooklyn Bridge, which is only a few hundred feet from the Hall of Records. The Bridge lighting comes on just about the time that the load in the Hall of Records falls off, and is at present on Edison service, but, as we understand, the contract is made from year to year, and could be very easily taken over by the city.

The most important proposition, however, is with regard to the new Municipal Building, located just across the street from the Hall of Records. The electrical requirements of this building will be considerable as, in addition to the lighting, there are thirty-four electric elevators, and it is expected that it will be ready for occupancy during the coming winter. In its basement there have been installed about 1700-hp. in high-pressure boil-

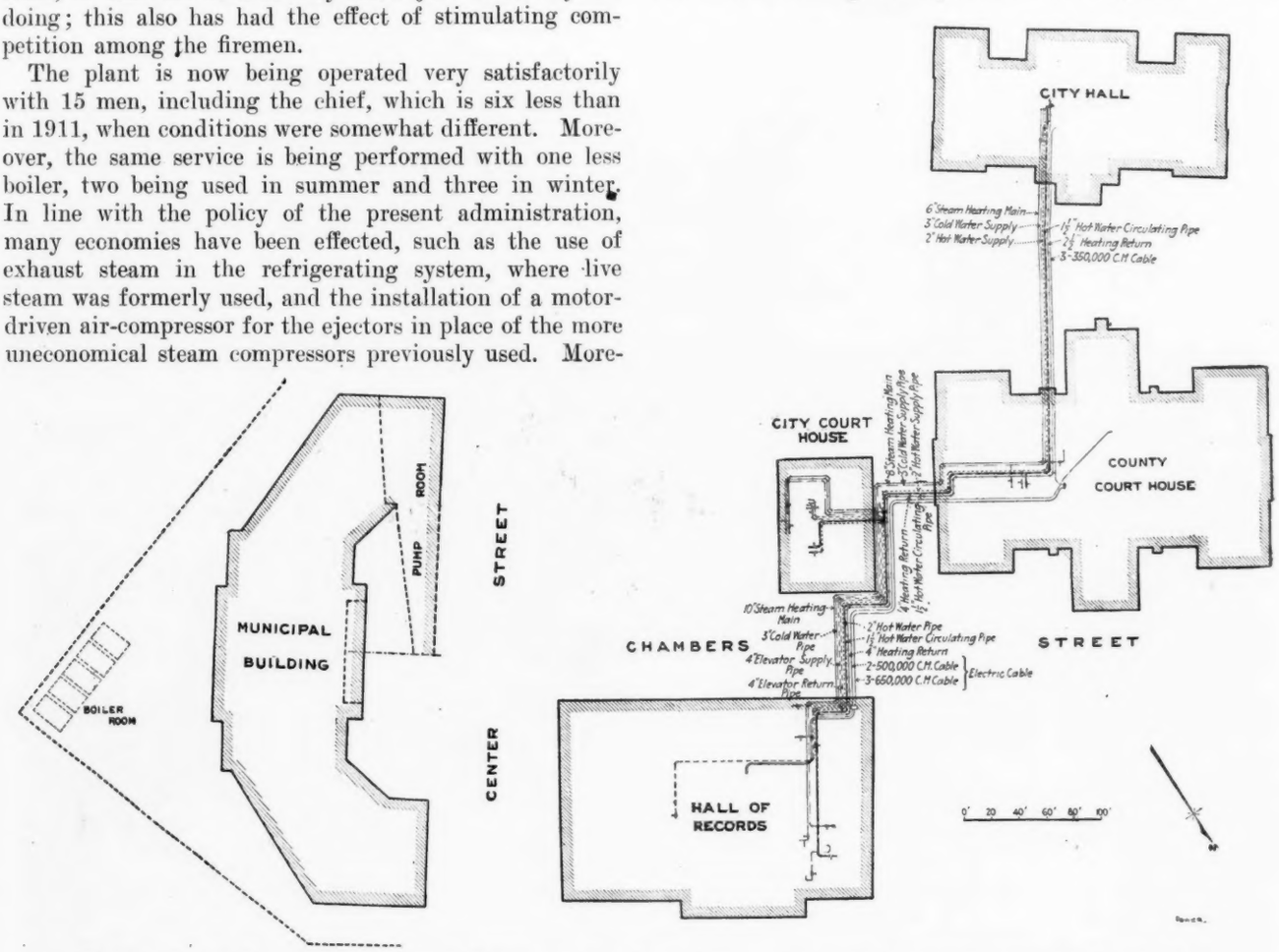

FIG. 4. PLAN SHOWING RELATIVE LOCATION OF CITY BUILDINGS AND SERVICES ALREADY INSTALLED

GROUP OF CITY BUILDINGS IN AND AROUND CITY HALL PARK

ers, with a complete pump equipment for various services and a 25-ton ice machine, but no engines or generators. A very complete switchboard has been installed, and Edison service is connected. Owing to the subway passing through the basement of this building, the space is somewhat cut up, as may be seen from the general plan, Fig. 4, and it was a question at the time whether enough space was available for an engine room. At any rate, the engines and generators were omitted.

Such being the conditions, it seems only logical to run a tunnel under Center Street and connect the boilers with those of the Hall of Records, installing such additional units as may be necessary in the basement of the latter building, where there is plenty of room, and supplying both buildings from the one plant, an arrangement which would cut down both labor and fuel expenses. The final outcome as to this suggestion may be governed by the results of the present test in the Hall of Records.

Elliott Vertical and Horizontal Heaters

These heaters contain the combined desirable features of the old Pittsburgh feed-water heater and numerous improvements made by the present manufacturers of the Elliott heater, the Elliott Co., 6908 Susquehanna St., Pittsburgh, Penn.

An examination of the accompanying illustrations shows simplicity of design and convenience in operation. With the exception of the bolts and brass fittings the heaters are built entirely of cast-iron.

The vertical heater, Fig. 1, is made with dished upper and lower heads, the top head being provided with a vent for removing accumulated air and gases in the heater. There is also an enlarged passage between the inlet nozzle and the heater, at the top of which is a combined oil separator and cutout valve. The oil and entrainments abstracted from the exhaust steam by the separator pass into an overflow box, below, from where it flows to waste through a water-sealed opening. The overflow box not only serves as a deposit chamber for the condensation and oil, but the large opening in its front face next to the water provides an overflow and skimmer to the heater. If back pressure is carried on the heater, the outlet to this chamber is provided with a float-actuated trap.

Water is admitted through a balanced valve controlled by a ventilated float, and is discharged through a cast-iron conduit to the spray box, from which it is discharged to the pans. This spray box has four or more V-shaped arms with saw-tooth edges, Fig. 2, over which the water flows to the top distributing pan. Because of the construction of the pans the water is broken up as it passes over and drops into the water space below, during which passage it reaches its maximum temperature.

Referring to Figs. 1 and 4, water drops from the arms of the spray box into the distributing pan and then flows in an outward direction, falling from cascade to cascade until it passes over the outer edge into the sediment pan below. It then flows in an inward direction, falling on another cascade pan beneath, and so on until it finally drops into the water chamber. As the water falls over the edges of the cascade pans, it is broken up a number of times, and in approaching the outer edge its depth gradually decreases, until in the form of a thin sheet, it passes over the outer edge into the pan beneath.

The pans are supported on a central column and each individual set is rotatable about its center casting independently of the adjacent set. The cascade pans are made in two sections bolted together, and are not intended to be removed from the heater. The sediment pans, however, are built in segments, Fig. 5 the number and size depending upon the size of the heater. They are fastened to the cascade pans and are easily removable through cleaning doors on the side of the casings. The cascade pans consist of annular steps, the sediment pans

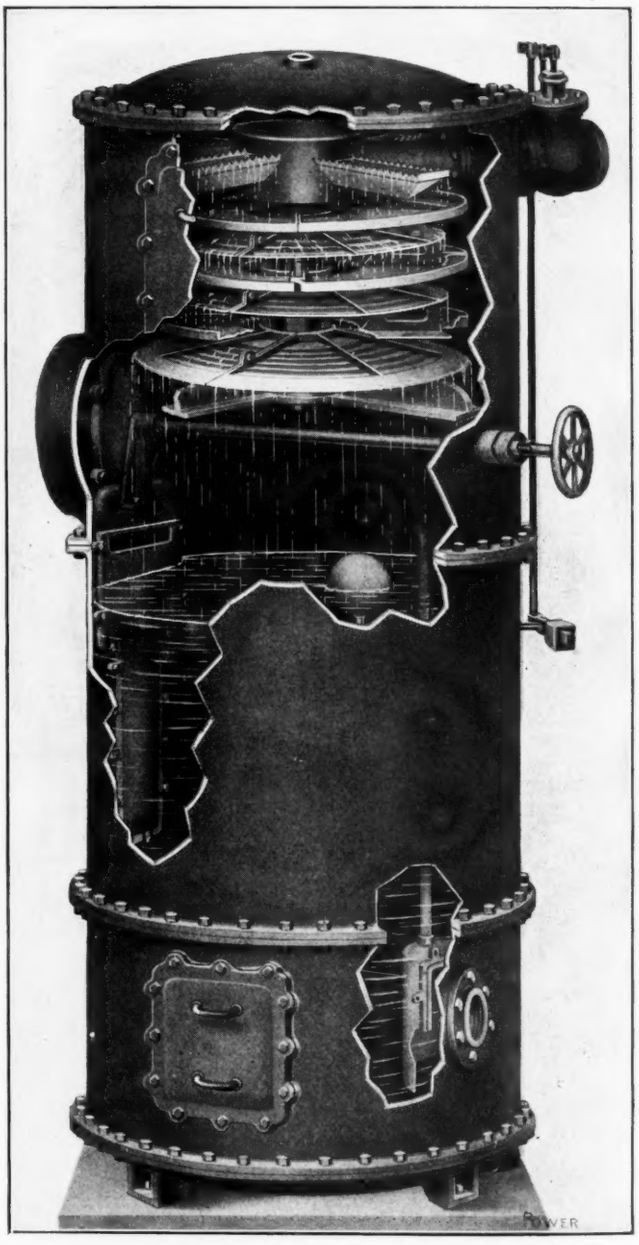

FIG. 1. SEMI-SECTIONAL VIEW OF VERTICAL HEATER

slope toward the center and catch precipitates released by the heat of the water. In order to clean the pans each is rotated in front of the cleaning door, the absence of the sediment-pans segments allowing ample room for scraping off any scale that may have formed.

The combined separator plate and cutoff valve is shown in Fig. 6. It is made with a corrugated surface against which the incoming steam impinges, abstracting the oil and entrainment which are deposited in the overflow box.

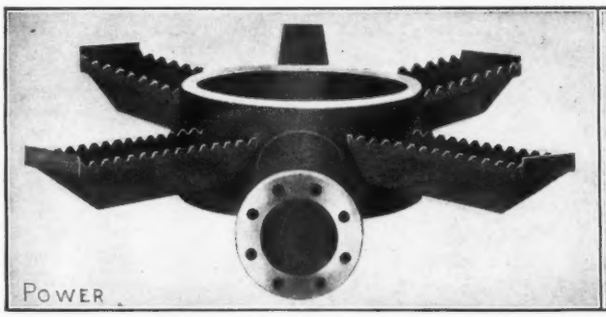

FIG. 2. SPRAY BOX

FIG. 3. OIL SEPARATOR

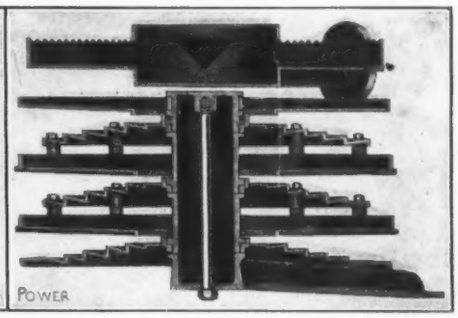

FIG. 4. DISTRIBUTING TRAYS

The separator is mounted on studs and by removing the nut can be removed and cleaned after becoming filled with grease and oil. The face of the oil separator is shown in Fig. 3.

The cutoff valve permits of cutting out the heater for cleaning. A bronze ring inserted in one of the outer grooves of the oil separator acts as a valve ring and bears on the valve seat in the steam nozzle of the heater. The combined valve and separator slides on its supporting studs. One end of the valve stem extends through the separator and cross bar which is threaded and engages with the threads on the end of the valve stem, which is also connected to the valve spider. The other end extends through the wall of the heater and is provided with a valve wheel.

Cold water enters the heater through the inlet valve already mentioned, and the rising and falling of the float opens and closes the valve in a proportion sufficient to maintain a constant water level in the heater. The return condensate from the heating system enters the heater through an opening between the cold-water inlet valve and the heater, the condensate passing over the heating pans in the usual way to insure the highest temperature.

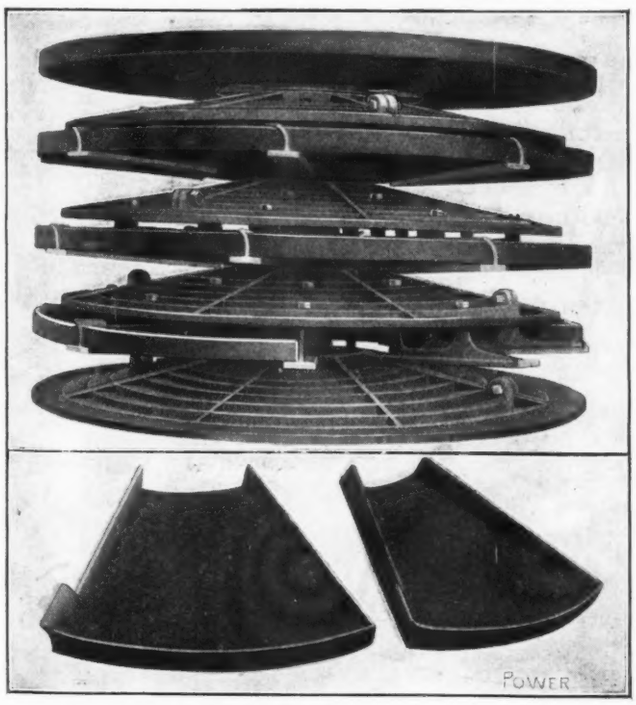

FIG. 5. SEDIMENT PANS

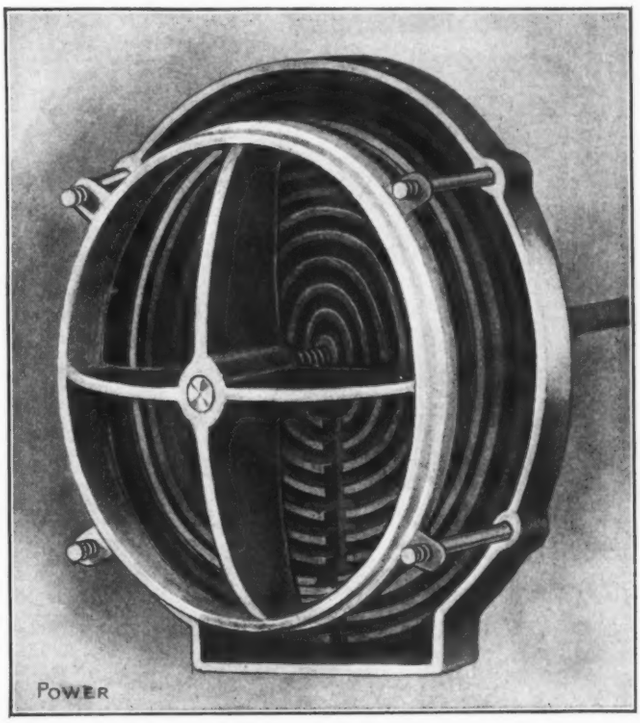

FIG. 6. COMBINED SEPARATOR AND CUTOFF VALVE

To simplify piping a tee separator can be attached to the heater, the purpose of which is to purify the steam that does not enter the heater, but which is used for other purposes, such as steam drying, heating, etc. When the heater cutout valve is used and the steam is shut off from the heater all the steam is purified up to the capacity of the main exhaust line. The tee-type separator can be placed at any convenient point in the exhaust line leading to the heater.

This type of separator is also built in such a way that the valve and separator plate are in one piece so mounted that it can be readily removed through the opening at the top when it becomes fouled and requires cleaning. Fig. 7 shows a section through a tee-valve separator designed for a horizontal exhaust main. On one side of the tee is a separating plate containing a combined valve and valve disk operated by a valve stem which passes through one side of the tee. The outlet to the separating chamber is provided with a bronze seat for the valve disk.

A combination of tee-valve separator and back-pressure valve is shown in Fig. 8. The back-pressure valve is attached to the top outlet of the separator, when the

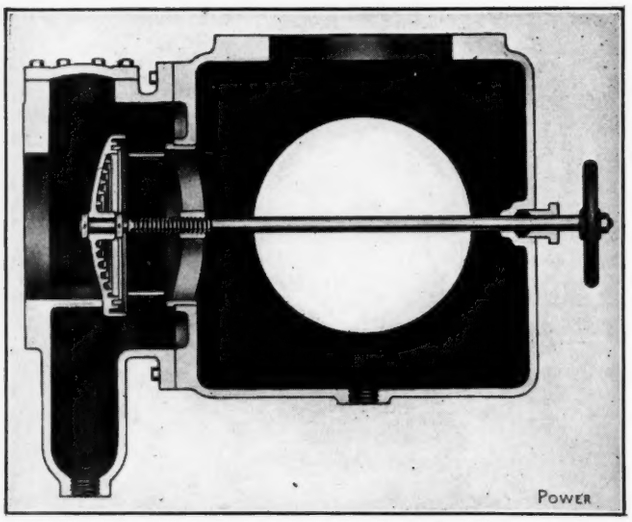

FIG. 7. SECTION OF TEE-VALVE SEPARATOR

apparatus is mounted on the heater. The control of the heater and heating or drying systems is centralized at the heater, as shown.

In the design of these heaters it will be noted that all the space within is utilized for maintaining the proper head of water above the pump suction, and for providing ample area for distributing the steam to the pans. There is also a sufficient amount of steam space between the walls and pans and between the different pans, to allow for the required supply of steam, as well as for a sufficient area of the water surface to permit of precipitating the impurities before the water is drawn from the heater and forced into the boiler.

These heaters are made in various types, vertical, rectangular, cylindrical and horizontal. The vertical rectangular heater is built in small sizes only, and is suitable for small installations, occupying, as it does, but very little floor space and headroom. The main body of this heater is made in one casting, the back is closed by a plate containing the nozzle, overflow, etc. The body and plate are bolted together; the pans, water supply and separators are built on the same lines as in the heater already described.

The horizontal cylindrical heater is designed for use in power plants where headroom is limited. It is built on substantially the same lines as the vertical type, the difference being that the shell is placed horizontally instead of vertically. A view of this heater is shown in Fig. 9. The flanged sections are cast, machined and bolted together; doors permitting access to the interior for cleaning are provided on the right-hand head, and on the side walls of the cylinders. Water enters the heater through a balance-float-controlled valve, shown at

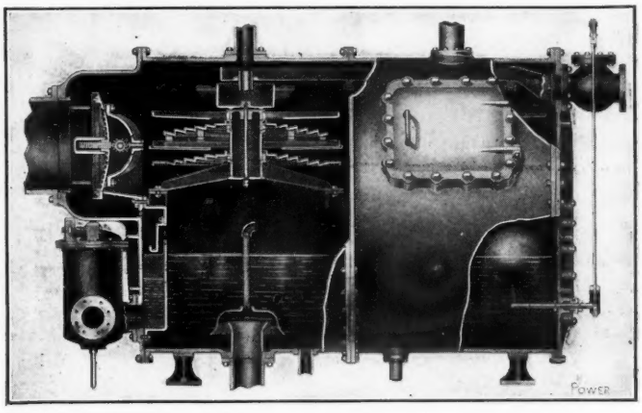

FIG. 9. SEMI-SECTION OF HORIZONTAL HEATER

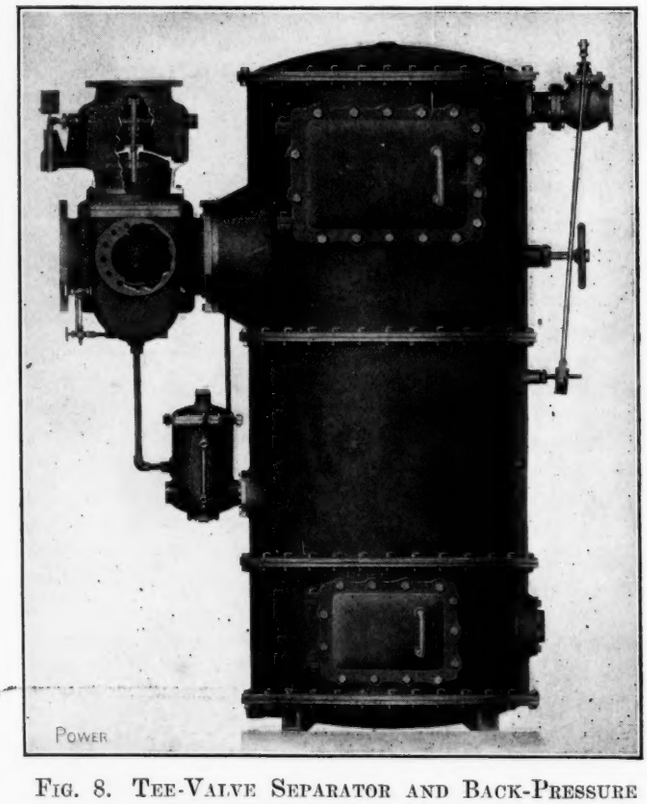

FIG. 8. TEE-VALVE SEPARATOR AND BACK-PRESSURE VALVE ATTACHED TO HEATER

the right-hand head, and is discharged into a conveying trough, and distributed through adjustable nozzles to the several sets of pans. The nozzles can be adjusted to obtain an equal supply of water to each set of pans. The combined valve and separator already described is shown at the left, the valve being operated by a handwheel extending through the wall of the shell. The hot-water outlet is covered by a hood and vented to the steam space. This is to prevent the entrance to the pump section of any light particles which might float on the surface of the water. Each section of the heater is provided with a blowoff connection at the bottom of the cylinder. This type of heater is built in sizes up to and including 12,000 hp.

Fig. 10 shows one method of supporting the heater, also that of attaching the cutoff valve and overflow trap.

A feature shown in the horizontal cylindrical heater, which is built for large capacities only, not found in those already described, is that instead of controlling the supply water by one large valve, several valves are used. These smaller valves are actuated by floats placed in outside float boxes, where they are not affected by the pulsation of the steam in the heater.

As shown in Fig. 11, the water enters in front of the central valve and is distributed in equal quantities to the three valves. As the capacity of each spray box and its pan system is equal to the capacity of the valve, it does not matter so far as the final temperature of the water is concerned, whether it is distributed to the dif-

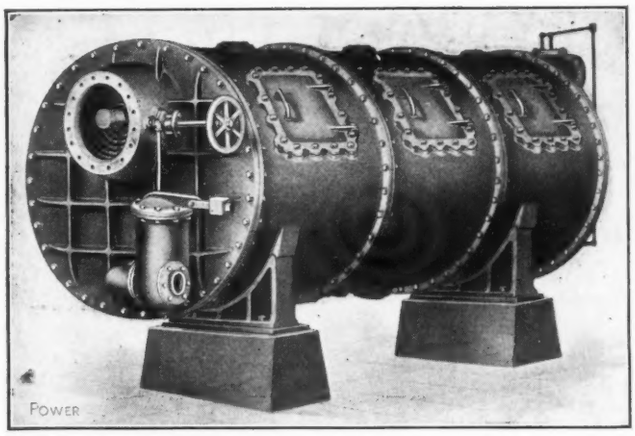

FIG. 10. HEATER AND CRADLES

ferent system pans uniformly or not. By the use of a number of small valves, the supply of water is more uniformly in proportion to the demand than it would be if one large valve were used for the same total capacity.

It is necessary for a valve to accumulate energy sufficient to overcome the friction on the connections between the float valves and the valve combined with the inertia of the valve parts, etc., before it begins to move the valve. Consequently, the control of the water is much more sluggish when using a large float-operated valve than when using a number of small ones. Multiple valves also tend to give a more constant water level, thereby avoiding a sudden rush of cold water into the heater at times when there is not a sufficient amount of steam to heat it. This type of heater is made in sizes from 15,000 to 50,000-hp. capacity.

At times it is desirable to connect up two or more heaters in multiple, and when so doing, it is necessary that the proper proportion of steam be supplied to all of the heaters, and that equal water levels be maintained. This method of connection is illustrated in Fig. 12, where two heaters are mounted in line and the exhaust nozzles connected to the inlet nozzles in such a way that the supply of steam can be controlled by the cutoff valve within the heaters. In plants depending upon auxiliary exhaust steam for heating the feed water, it is necessary at times to supply the heater with live steam.

This is accomplished by placing within the exhaust connection at *D*, a tee branch connected to the live steam supply. As the tee discharges the live steam directly in line with the entrance to the heater, it acts as an injector in increasing the velocity of the entering exhaust steam.

Referring to Fig. 12, *E* is a junction box, *F* is the pump suction outlet, and *GG* are check valves opening inward. The float-control valves are actuated by the variation of the water levels within the two heaters. If for any reason the level in one heater should drop below that in the other, the difference in heads prevents the check valve controlling the outlet of the water in the low heater from opening, and remains in this condition until the water levels in both are equal. In such a case the water should flow at a uniform rate from both heaters into the junction box, and from there to the pump. The main inlet *H* takes the supply from the hotwell. Back of the nozzle *H* is a valve controlled by the float in the

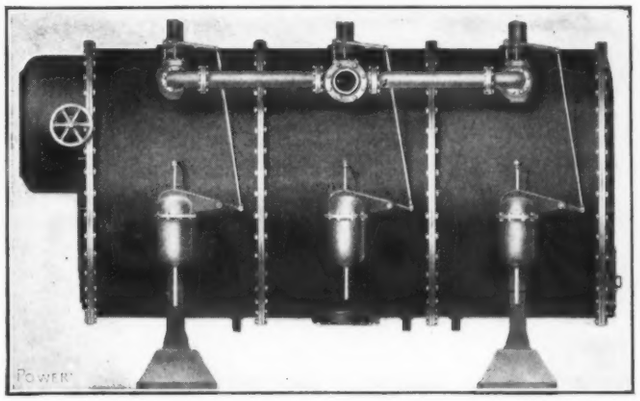

FIG. 11. TRIPLE INLET VALVES

float-box *J*. Should the supply of water from the hotwell be insufficient, the water in both heaters falling to the same level, causes the floats in the float-box *J* to drop and open the valve *K*, admitting raw water. The advantages of connecting two heaters in this manner are that the piping is simplified, that the cost of installation is reduced, an equal water level maintained in the heaters and the proper amount of steam can be supplied to each heater.

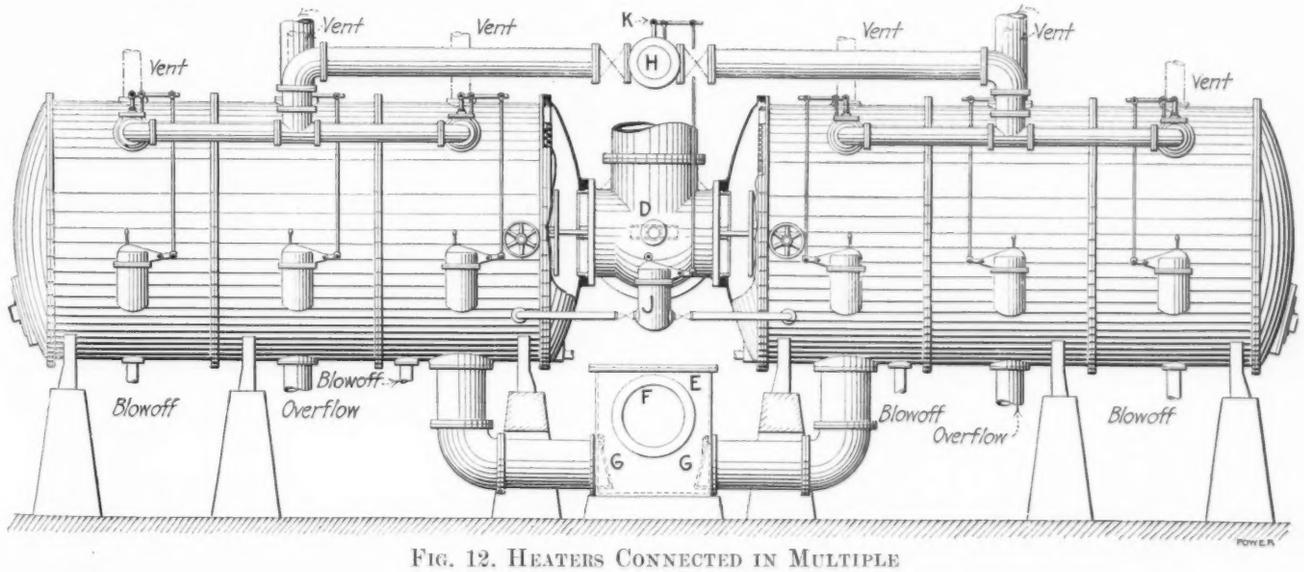

FIG. 12. HEATERS CONNECTED IN MULTIPLE

Damage by Water in Engine Cylinders

SYNOPSIS—It was found by actual experiment, that due to a relatively short period of admission as compared with the period of exhaust, and to the exhaust ports being larger than the inlet ports, all the water passed out of the cylinder without doing any damage. At light load, however, water might be drawn back into the cylinder from the exhaust pipe and cause damage.

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In POWER, June 25, 1912, was published an article explaining how the low-pressure cylinders of compound engines are wrecked by water which accumulates in the receiver and is swept into the low-pressure cylinder. This explanation was questioned by H. Bollinckx, the eminent Belgian engine builder (see July 30, p. 164) "because the admission being only 0.3 of the stroke, the water cannot enter except during this period, but it has at least 0.8 of the stroke to get out of the cylinder. How, therefore, can it stay there to make trouble on the return stroke?"

M. Bollinckx, in order to satisfy himself and others of the soundness of his position, undertook a series of experiments to ascertain if it were possible to wreck an engine in this way. The engine used is shown in cross-section in Fig. 1. The diameter of the cylinder was 13.75 in., the stroke 27.5 in., the steam pressure 110 lb., and the rated capacity 140 hp. at 158 r.p.m. The distribution of the steam was by means of horizontal piston valves controlled by a cutoff mechanism for the admission and a positive drive for the exhaust. The governor controlled the admission up to 55 per cent. of the stroke, release taking place at 90 per cent., the valves closing for compression when the return stroke was 75 per cent. completed. The clearances were about 3 per cent., and both the barrel and the heads were jacketed by the live steam. The tests were made in the presence of MM. Vincotte and Dubois, directors of the Association *pour la Surveillance des Chandieres a Vapeur.*

In order to allow the ready escape of the water taken into the cylinder, the exhaust pipe of 6.7-in. diameter, was installed with a considerable pitch away from the engine and discharged into the atmosphere. Precautions were taken to limit the amount of damage that might be produced. The engine was run single-acting, the head of the operating end held by only three bolts, and an abutment provided to take care of it should it be blown off. The engine was belted to the shafting of the shop which was run by a much more powerful engine, so that its speed was held at that determined by the shafting regardless of the point of cutoff, which could be adjusted by hand. Three boilers were used in connection with the test, two to supply the engine with steam and one at a higher pressure, from which water was drawn for injection into the incoming steam.

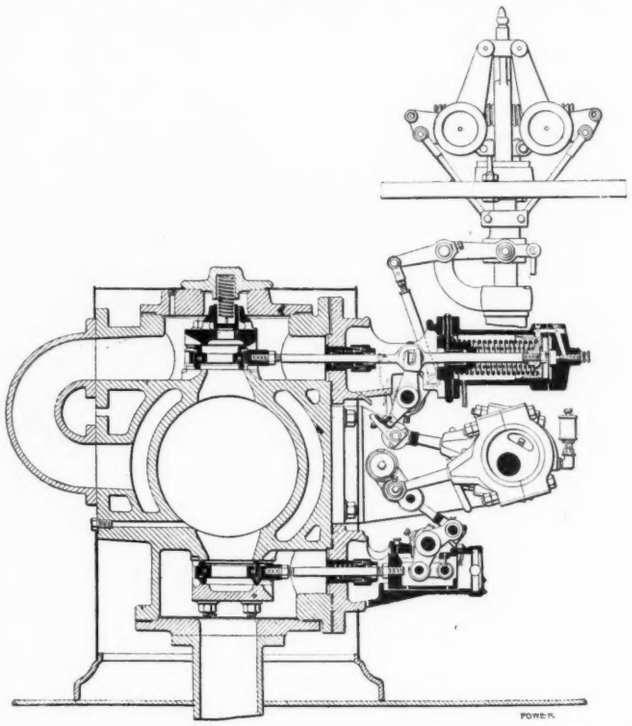
The steam main was 4.35 in. in diameter and 33.8 ft. long. One valve was provided near the boilers, and another near the cylinder of the engine, by which means it was possible to operate the machine from a distance when necessary.

The tests were divided into three series, in the first of which water was pumped into the steam main by a pump 2.75x4.5 in. running at 200 r.p.m.

For the first run the machine was started with a very early cutoff but carried at speed by the belt. The pump was started and discharged its water into the steam main and after passing through the jackets the admission valve and the cylinder itself, it was voided continuously by the exhaust pipe without having produced any damage.

For the second run the degree of admission was augmented slowly and progressively, while the pump continued to discharge water into the steam pipe. The results were the same as in the first test.

For the third run the belt was removed, in which case the engine naturally speeded up as it was given steam



SECTION THROUGH ENGINE UPON WHICH TEST WAS MADE

and as the degree of admission was increased. But even in this case there was not the least shock although the pump was discharging the water continuously.

The second series of tests was made by installing in the steam pipe near the engine a pocket having a volume of approximately 50 quarts, connected by a pipe with the water portion of one of the boilers. This boiler was run at a higher pressure than that supplying the engine, so that by opening the valve in the connecting pipe its water could be discharged into the incoming steam at any rate desired. A water gage in the pocket permitted the movement of water in the pipe to be seen.

In the first run with this arrangement the valve was opened so as to entirely fill the pocket with water. The result was that it came through the engine without damage but in gulps instead of continuously as when fed regularly by the pump. The alternating movement of the water in the pocket was visible in the gage glass. The valve was then opened so as to fill the pocket only partly full. The water came out of the exhaust pipes still in gulps but in lesser volume.

In the next experiment the valve was opened as rapidly as possible to such an extent that the steam pipe was entirely filled with water, as well as the steam jacket. The water came through the engine all right but the first slug was thrown a distance of some 65 ft., and at the same moment there was a shock in the pipe accompanied by the rupture of one of the joints. The pipes separated some ten inches and shortly after another slug of water came along and was discharged through this opening. The exhaust pipe was then repaired and the experiment repeated when the water escaped from the exhaust pipe in successive slugs. The engine was run with various degrees of cutoff and suffered not the slightest damage.

A third series of experiments was made without the jacket. With the engine in this condition all sorts of experiments were made, the steam pipe was filled with water more or less completely, and the machine was run fast and slow with short and long cutoff, but always passed the water without harm.

The conclusion at which the experimenters arrived was that all water which enters a cylinder of a steam engine during the admission is discharged during the exhaust stroke without occasioning any injury to the cylinder regardless of the quantity of the entering water or the load of the machine. This conclusion entails the supposition that the exhaust valves are placed in the bottom of the cylinder.

This is explained by the fact that the admission rarely lasts more than one-half stroke while the exhaust continues during almost the entire return stroke, and the exhaust passages are larger than the steam passages.

It might be suggested that the water would enter the cylinder faster than it would discharge because it enters under the difference in pressure between the interior of the cylinder and the boiler. As a matter of fact, however, at the instant of opening of the admission valve, this difference in pressure is not very great because of the pressure in the cylinder at the end of the compression. The discharge of water from the cylinder is favored by the difference in pressure between the interior of the cylinder and the exhaust pipe, and it should be remarked that the pressure is small for a light load, that is to say for early cutoff, but the quantity of water taken in is also small in this case. The experimenters enumerate the following conclusions:

1. Single-Cylinder Non-Condensing Engines—No damage from water can result if the exhaust pipe is well drained. If water remains in the pipe it will return to the cylinder, especially when the engine is running light and the pressure of the steam at the end of the stroke is less than that in the exhaust pipe.

Precaution—Place at the foot of the exhaust pipe a large pocket, in which the water may accumulate and be careful to see that it is kept empty by a trap or otherwise.

In small installations the exhaust steam from the engine is used to heat the feed water. This process is evidently economical but to avoid accidents to the engine therefrom it is indispensable that the heater be well designed.

2. Single-Cylinder Condensing Engines—Two cases are to be considered, engines with a condenser in tandem and engines with the condenser below.

In the first case the water can accumulate in the pipe between the condenser and the cylinder because this pipe is closed at both ends and forms a pocket. The water brought in with the steam and which accumulates in this pocket if precautions are not taken against it, may be drawn into the cylinder and occasion a water shock. This accident is likely to happen at the time when the engine is being started up or when the load is very much diminished. It is the practice of the Bollinckx shops to place a steam loop upon this pocket, in order to keep it continually empty.

A water shock may happen to this sort of an engine from a defect in the air pump or through mismanagement, such as neglect to close the injection. The precautions recommended are to carefully drain the pipe and to provide a vacuum breaker.

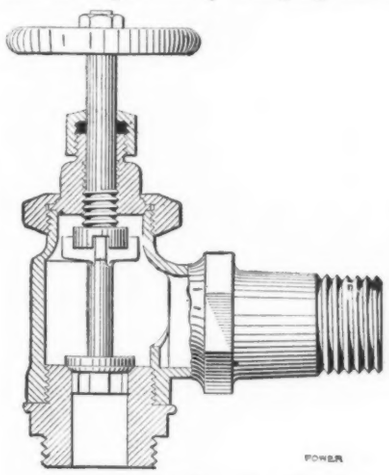
For compound condensing machines, damage by water may be suffered in the high-pressure cylinder by reason of insufficient drainage for the receiver, and every precaution should be taken to see that it is well drained.

Although it is true that water entering by the steam pipe will not produce a damaging shock in the cylinder, it is well that the pipe connecting the engine with the boiler be provided with well drained separators.

Osman Regrinding and Pressure-Equalizing Boiler Check Valve

This valve consists of a slotted head made solid with the valve stem. The slot in the head drops automatically over the projection of the valve body. On screwing out the valve stem, the valve can lift from its seat.

The seat can be reground by bringing the clutch head



Regrinding Check Valve

into action on the valve wings, and screwing in on the valve stem until the disk and seat are in contact, after applying to the valve seat a small amount of emery or ground glass. This operation can be accomplished without removing the valve body or any parts except to momentarily loosen the combination nipple and seat.

The valve, which is made by Gustav A. Osman, Decorah, Iowa, has a combination nipple and seat, which is screwed into the body, thus permitting of removing the seat for repair or examination.

The bridge construction at the port entrance of the stem to the valve chamber equalizes the distribution of steam pressure under the disk, thus preventing oscillation of the disk and eliminating the tendency of excessive wear on the side of the disk nearest to the port entrance of the stem to the valve chamber.

New Manifold and Mixer for CO_2 Recorders

By Morgan B. Smith

SYNOPSIS—One CO_2 recorder will serve satisfactorily four boilers if the gases are thoroughly mixed in the devices described herewith.

In a great many boiler stations the need of a CO_2 recorder is felt, but considerable hesitancy is almost always shown to purchase a single recorder where there are more than one or two boilers. As a matter of fact no such hesitancy should be shown, for it is a proven fact that a single recorder operating on as many as four boilers is a good investment, providing the results are followed up with the firemen. Of course, one recorder for each boiler is the ideal installation, but with a proper mixing of the gases from two to four boilers much valuable data may be obtained.

In a number of plants with which the writer is familiar, it is the custom to hitch up four boilers with each recorder, sending the combined gases, after thorough

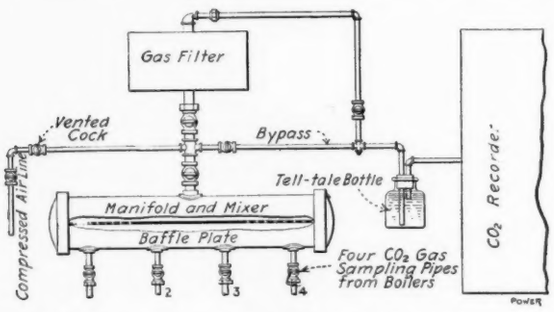


Fig. 1. Connections to Manifold Mixer

mixing, to the recorder, which then analyzes the gases for CO_2, and so gives a measure of the combined efficiency of the four boilers.

In these same plants it is also the custom to send the gases from one boiler to the recorder for periods of from two to seven days in order to get a general average of the performance of the single boiler. By switching from one boiler to another it is possible to keep very close record on the individual efficiency of single boilers in a large plant with only one recorder to each four boilers.

The new manifold is in reality a combined manifold and mixer. The manifold is not as efficient a mixer as the mixer proper but is especially useful where the recorder suction is somewhat weak owing to lack of head in the water supply or for other reasons is unable to overcome the back pressure imposed upon the system by such a device as the mixer proper.

Fig. 1 shows the manifold, as now installed in several power stations in the State of Michigan, together with the necessary connections, etc. The manifold proper consists of a length of 2½-in. iron pipe 18 in. long fitted with gas-tight caps at each end. The gas sampling pipes from the boilers, four to a manifold, enter the lower side and are spaced equidistant from each other. These sampling pipes are ¾ in. in diameter and are fitted with asbestos-packed cocks.

Within the manifold is placed a baffle plate of flat iron perforated at each end with a single row of $\frac{3}{16}$-in. holes, leaving a strip of solid metal at the center. This piece is 18 in. long and lies within the larger pipe in a horizontal position. Its width is 2¼ in., so that it lies a little below center in the manifold.

As apparent in the sketch gases from boilers 2 and 3 are thrown to the ends and are forced to mix with the gases from boilers 1 and 4, passing upwards then through the holes in the baffle plate into the large space above the baffle plate, from which the exit pipe carries the combined and mixed gases to the gas filter above.

Between the manifold and the filter is placed a cross fitting with a. p. cocks on three legs, so that the filter may be bypassed when necessary and so that the gas sampling lines from the boilers may be blown out with compressed air at regular intervals.

At the lower side of the cross shown at the junction of the regular gas line after the filter and the bypass, is shown a plug, which may be removed readily, and the whole line cleaned. This is also a handy place to attach the sampling tube of the Orsat CO_2 analyzer when it is thought necessary to check the recorder.

In the compressed-air line, by means of which the whole system of sampling pipes and manifold may be blown out at regular intervals, there is a vented a. p. cock between the ordinary a. p. cock and the line between the manifold and the filter. This is simply a precautionary feature serving to protect the gases passing between the manifold and the filter into the recorder from dilution with air from the compressed air line. Needless to say this vent cock is faced in such a manner as to take care of any leakage from the air line.

It is readily seen, by reference to Fig. 1, that any one or all of the gas lines from the boilers may be blown out whenever desired and that gases from one or more of the boilers may be sent through the manifold mixer and analyzed in the recorder.

Throughout only asbestos-packed cocks have been shown, no valves whatever, as it has been found by repeated tests that valves are not as well suited to such utilities as cocks. Only such cocks should be used as are reliable, for any leaks past these cocks will be noted by the recorder and wrongly charged up against the combustion.

The ordinary tell-tale bottle shown just ahead of the recorder needs no comment beyond stating that it is used merely to show the rate of gas-aspiration through the manifold and to detect stoppage in the gas lines. Only one is shown, there being another such bottle connected in parallel with the one shown, which acts as a seal so long as the sampling lines are open, but which immediately blows when a stoppage occurs. The filter is provided with unions above and below so that it may be easily removed for cleaning and repacking.

The mixer is more complicated than the manifold mixer just described, but gives better mixing, and, where the suction provided by the recorder is sufficiently strong to overcome the added back pressure on the system, is to be preferred in many ways to the manifold mixer.

The principle involved is that of the gas scrubber, inasmuch as the gases, rising through the mixer, are forced back and forth from the center to the sides and back to the center, etc., by means of baffle plates. These baffle plates are perforated with many ⅛-in. holes concentrically, leaving a solid circular area at the center

about 1½ in. in diameter. The number of baffle plates in the mixer may be varied according to the amount of gas passing, the ordinary arrangement for gases from four boilers being from four to six baffles.

The body of the mixer consists of a piece of 4-in. pipe about 10 in. long fitted with caps at each end through which pass the inlet and outlet pipes. The baffles are so built that they support each other and are readily removable for cleaning from time to time. Fig. 2 shows the general design of the mixer.

The baffle plates may be easily made from sheet brass or galvanized iron. They are then fitted with the legs which also act as spacers. All the baffle plates may be soldered together as a unit or in pairs consisting of one flat baffle and one curved baffle. They should be so fitted that they make a fairly tight joint with the inner walls of the containing pipe, but must be readily removed for cleaning from time to time. It is necessary to use a manifold between this mixer and the boilers so as to combine the gases before entering the mixer. It has been found that this type of mixer gives excellent results, the only feature not always feasible being the added back pressure on the system.

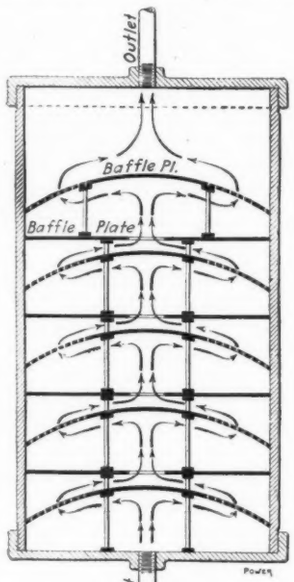


FIG. 2. GENERAL DESIGN OF MIXER

The foregoing descriptions are given in the hope that they may be of value to plant operators who are hesitating with regard to the advisability of purchasing only one recorder for their plant when they feel that a larger number is really imperative. The writer can assure such operators that very good results may be gotten from one recorder to each four boilers if the gases are properly mixed before entering the recorder.

It is hardly necessary to make note of the fact that the rates of aspiration of the gases from the several boilers must be nearly the same in order that the resultant mixture of gases may be an average from the several boilers. A tell-tale bottle placed in each sampling line between the boiler and the manifold or mixer will tell at a glance the rate of aspiration by the number of bubbles observed per minute.

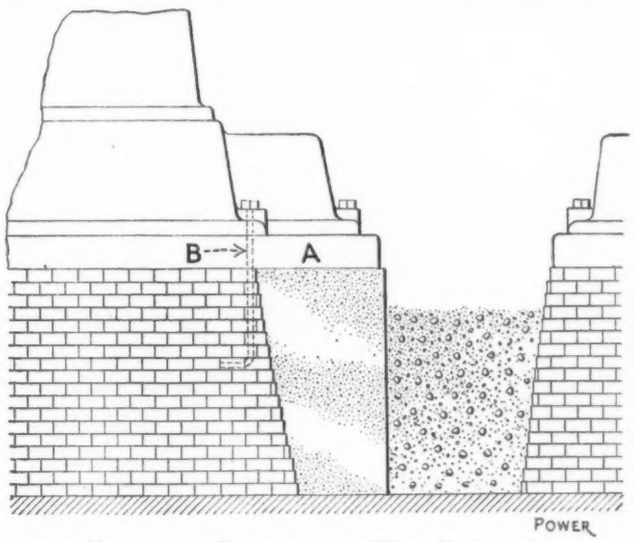
Periodical and regular checking of the recorder and the piping by means of the ordinary Orsat analyzer or similar device is important. Unless one knows that the piping is airtight and that the recorder is actually giving correct results, within the limits of such apparatus, all precautions as to correct sampling and mixing are useless and results valueless.

The above-described manifold mixer was designed by W. G. Connelly, chief engineer of the Rapid Railway Co.'s power station at New Baltimore, Mich., for use with the recorders at that station, and has been in service a sufficient time to have proven its adaptability and value for such a utility. Some modifications in the original design were made by H. L. Scheibner, assistant combustion engineer with the Detroit United Lines, of which the Rapid Railway Co. is a part.

Building an Addition to a Foundation

BY W. H. WAKEMAN

The designing engineer of a certain steam plant laid out two foundations for two direct-connected units which were properly laid down, and foundation bolts were placed



HOW THE FOUNDATION WAS EXTENDED

in both foundations, but only one was utilized at the time. After several years more current was wanted, and a different unit was purchased which required a larger foundation, as shown at *A* in the illustration.

The cap on this foundation consisted of a granite block about 12 in. thick, which required additions at one end and side. Earth was removed from between the two original foundations and the space filled with a mixture of crushed stone, cement and sand, which stood for several weeks before the new engine was started. An excavation was also made at the end of the old foundation and the space filled with a concrete mixture.

Extensions for the capstone were made of granite blocks and accurately fitted, care being taken to have them firmly imbedded in the cement. The top of the foundation addition was left rough to afford a good hold for the fresh cement, this method of construction offering less chance for settling. The original foundation was eight years old at this time, and having become very hard, would neither shrink nor settle, although the addition did before the granite cap was laid.

Some of the original foundation bolts were utilized, but four new ones were put in, three of which came in the edge of the old foundation as shown at *B*. They were cemented in place so that it is impossible to pull them out by screwing down the nuts. The other anchor bolt was fitted with a square head and large washer and imbedded in the concrete.

This unit has been in service for about two years, and cracks have developed between the main capstone and the additions, thus showing the benefit from giving careful attention to details.

Revelations of Some Damaged Boilers*

Altogether eighteen cases of accidents were taken up, five of which were fully investigated, as follows:

A. A lower shell plate of a double-flue boiler built in 1892 for seven atmospheres (above atmospheric) pressure, with a heating surface of 979 sq.ft., after being started up for three hours on blast-furnace gas and under three atmospheres pressure, was ruptured in the fourth girth seam. The crack extended over eight rivet holes and ran into the solid plate, so that the boiler was emptied.

The investigation showed that the material cannot be pronounced inadequate, but that the rivet holes were punched. It is to be assumed that fine cracks were thus produced and gradually increased during service, finally leading to a complete break. Such fine cracks were noticed extending from the parts distorted by punching.

B. The second case was that of a front head of an eccentric corrugated flue boiler of 862 sq.ft. heating surface, built in 1902 for 12 atmospheres pressure. After renewing the first flue section, which had been bent somewhat by use of oil and grease and much bent by the hydraulic test which followed, a crack in the round corner at the edge of the flue was observed at the time of cleaning. This crack was almost through and extended over half of the head.

The neighboring parts were covered with numerous fine parallel cracks. It can well be assumed that the main crack was produced by extension and running together of such originally small ones. Nothing could be learned as to their cause. Perhaps very fine, unnoticed cracks were caused by the flanging of the head. Perhaps, also, a heavy stress on the head was produced by the bending of the bagged flue. The material tests all gave satisfactory results.

C. The third case concerned a shell plate from the last belt of a double-flue boiler of 915 sq.ft. heating surface built in 1908 for 8 atmospheres pressure. During cleaning it was noticed that water leaked from a crack. The test piece submitted was a part of the shell plate.

The belt in question lay on a baffle of the setting and showed cracks extending through the part supported near the girth seam, and also strong corrosion on the outside. By the various etching tests and photomicrographs it was perceived that the crack followed the edges of the ferrite grains, whence it is judged that the cracking was caused by strong alternate stresses upon the plate. This assumption is strengthened by the fact that the feed pipe ended just over the damaged place. The cracks are, therefore, very probably due to the circumstance that, in cleaning, cold water was let upon the not sufficiently cool plates. The composition of the material was shown by the tests to be normal.

D. The fourth case had to do with three shell plates of a double-flue boiler having 646 sq.ft. of heating surface, which was built in 1894 for six atmospheres pressure. At the time of a regular hydraulic test, leaks were found in the girth seams. On calking these places, a piece about four inches long broke out of the edge The rivets there were then removed and the piece chiseled out. Various cracks were now seen running from hole to hole of the seam and several cracks in the edges of the holes. After repairs, and during the hydraulic test, there occurred, at another girth-seam rivet hole, hair cracks which hardly were moistened. After this piece also had been cut out several cracks appeared not only in it, but also in the underlying plate.

Investigation shows that the rivet holes had been punched. It was determined also that the sheet was so bent that the punching burr lay outward. Thereby were produced, from the start, fine hair cracks extending from the rivet holes.

Ball-pressure tests of the material showed a considerably greater hardness at the edges of the rivet holes than in the other parts of the sheet, the hardness figures being 160 to 200 against 120 to 140. A bending test embracing two rivet-hole edges resulted in a smooth break at these edges. The sheet was, therefore, very brittle in the vicinity of the holes. This brittleness must have been caused at the time of riveting, perhaps by the heavy calking of the rivet heads. Several unfavorable circumstances have, therefore, coöperated here to form the cracks. In addition came a not altogether proper method of blowing off the boiler in shutting down, for the too sudden cooling produced strains. The percentage of oxygen, sulphur and calcium was found to be somewhat higher than is good practice today for boiler plates. Notwithstanding, the material, according to the other tests, could not be pronounced unsuitable.

E. The last case was that of three tubes in a water-tube boiler of 3229 sq.ft. heating surface, built in 1911 for 13 atmospheres pressure. It had been in service for 45½ shifts when a water tube of the lowest row ruptured for 10 in. The ruptured bulge was on the bottom and the tube was bent upward by the reaction. Several other tubes were badly bagged.

Right after the accident, it was determined that the metal of the ruptured tube at the place of the crack was not drawn so thin as elsewhere. In the back part of the tube was found thin scale; in the rear header of the tubes was a layer of scale pieces two inches deep.

By microscopic investigation it was found that at the bagged places a strong decarbonization and coarsening of the structure had taken place; the size of grain was six times as great as in the immediately neighboring parts of the tube, therefore, a sharp local overheating had occurred, and this had caused the tube to burst.

The 18 cases of accident submitted from September, 1907, to the beginning of 1912 occurred in 16 instances with stationary steam boilers, in one with a locomobile boiler and in another with a steam drum or tank. In the 17 boiler accidents the material was mild steel while the drum was made of wrought iron.

If the cases be classified according to the causes of the accidents, as they appeared upon the tests, in only two cases must the blame be charged to the material alone, while in a third case other conditions were superadded. In three more cases the cause of the disasters was faulty workmanship; a water tube called seamless proved to be badly welded and twice old welded cracks broke open again. In six cases the punching of the rivet holes is accepted as the cause, in another case faulty design—an inadequately stayed head. Too quick shutting down and introducing cold water into the insufficiently cooled boiler led to two disasters. In three more instances water tubes were burst by scale and overload.

*Report presented by Chief Engineer Bütow, for the committee on testing damaged boiler materials, to the Munich convention of the International Association of Steam Boiler Inspection Societies, June, 1912. Translated from "Glückauf," Mar. 1, 1913.

GAS POWER DEPARTMENT

Tests on Small Gasoline Engines

By F. M. and E. A. White

Since the commercial development of the internal-combustion engine, many experiments have been conducted on the larger types of engines for various purposes. The small-farm engine is a more recent development, but is now attracting the attention of people who formerly thought this a too elementary field for their endeavors. The results of the Winnipeg motor contest have brought about increasing interest in the application of power to the large farms of the Western states, but here again they have ignored the small stationary and semi-portable engines. As yet there is little knowledge in regard to the performance of the smaller types. This work was, therefore, undertaken to determine the fuel consumption in pounds per horsepower-hour for varying loads of the small (3- to 10-hp.) internal-combustion engine using gasoline as fuel.

For this work three general classes were selected, ranging in power from 3 to 4½, 5 to 7, and 8 to 10 hp. These, for convenience, were classified as 3-, 6- and 10-hp. sizes. Twelve engines were used, four representing each of the three general classes. With one exception, one engine of each class was obtained from the same manufacturer, and each engine was tested under no load, one-quarter, one-half, three-quarters and full load.

Description of Engines

Table 1 gives a brief description of the engines used in the tests which are numbered from 1 to 12.

The gasoline used had a specific gravity of 0.7386 (Baumé, 59.55) and contained 20,800 B.t.u. per lb.

Methods of Conducting Tests

The prony brake was used to apply the various loads and in order to obtain the quarter, half and three-quarter loads, preliminary tests were first conducted in order to find the maximum capacities of the engines. As the speed of an engine increases, with the same setting of the governor, under the lighter loads the resulting horsepower is slightly more than quarter, half or three-quarters of the maximum horsepower; in these tests the governor was not changed except on engines Nos. 2 and 3. The rated horsepower of the engine was not considered in determining the maximum load the engine could carry, as all companies manufacturing engines allow for 10 to 25 per cent. over the rated horsepower, and the results secured bear out this fact.

TABLE II. TEST DATA

Engine No.	Average R.p.m.	Brake Hp.	Lb. of Fuel per B.hp.-hr.	Pints of Fuel per B.hp.-hr.	Cost of Fuel per B.hp.-hr., cents	Piston Speed in Ft. per Min.
1	474		3.06			553
	464	1.33	1.56	2.03	0.04	541
	461	2.63	1.11	1.44	0.029	538
	455	3.90	0.87	1.13	0.023	530
	441	5.09	0.95	1.23	0.025	514
2	334		2.06			556
	341	1.78	1.07	1.39	0.028	568
	338	3.54	0.81	1.05	0.021	563
	333	5.23	0.72	0.94	0.019	555
	331	6.93	0.65	0.84	0.017	552
	334	7.63	0.71	0.92	0.018	556
3	326		3.52			597
	319	2.91	1.01		0.026	584
	313	5.72	0.75		0.019	564
	311	8.52	0.70		0.018	560
	319	11.65	0.62		0.016	584
4	467		1.06			467
	471	1.01	1.32	1.71	0.024	471
	462	1.97	0.98	1.27	0.025	462
	463	2.98	0.85	1.10	0.022	463
	466	3.99	0.98	1.27	0.025	466
5	374		2.72			560
	378	1.84	0.98	1.27	0.025	566
	374	3.63	0.82	1.06	0.021	560
	366	5.35	0.79	1.03	0.020	548
	346	6.72	0.96	1.25	0.025	518
6	330		2.23			550
	361	2.73	0.69	0.90	0.018	601
	359	5.24	0.70	0.91	0.018	598
	356	8.07	0.72	0.94	0.019	593
	355	10.33	0.67	0.87	0.017	591
7	429		0.97			500
	467	1.00	1.09	1.42	0.028	544
	458	1.96	0.89	1.16	0.023	534
	453	2.91	0.81	1.05	0.021	528
	436	3.74	0.99	1.29	0.026	504
8	427		1.52			534
	432	1.73	0.88	1.14	0.023	540
	423	3.38	0.70	0.91	0.018	528
	417	5.00	0.65	0.85	0.017	521
	402	6.42	0.65	0.85	0.017	502
9	360		2.17			540
	375	2.25	1.15	1.49	0.03	562
	372	4.46	0.88	1.14	0.023	558
	371	6.68	0.78	1.01	0.02	556
	365	8.76	0.74	0.96	0.019	547
10	438		1.77			510
	427	0.73	1.74	2.26	0.045	498
	428	1.47	1.15	1.49	0.030	490
	438	2.26	1.01	1.31	0.026	510
	417	2.50	0.99	1.29	0.026	486
	407	3.26	1.17	1.52	0.030	474
11	353		3.21			500
	350	1.66	1.38	1.79	0.036	495
	343	3.26	1.08	1.40	0.028	486
	339	4.85	0.89	1.16	0.023	480
	339	6.46	0.76	0.99	0.020	480
	362	7.76	0.88	1.14	0.023	512
12	323		6.15			538
	328	2.50	1.64	2.13	0.042	546
	325	4.95	1.02	1.32	0.026	541
	321	7.34	0.85	1.10	0.022	545
	303	9.15	0.92	1.19	0.024	505

TABLE I. ENGINE DETAILS

	Engine Number											
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
Type: Horizontal (H) Vertical (V)	V	H	H	H	H	H	H	H	H	H	H	H
Rated horsepower	3	6	10	3	6	9	3	5	8	3	7	9
Speed, r.p.m.	375	325	325	425	350	325	450	400	350	425	350	325
Size of cylinder, in.	4½x7	6x9	6¼x11	4½x6	5½x9	7x10	4½x7	5x7½	6x9	4½x7	6x8½	7x10
Diameter of intake valve, in.	1½	1¾	2⅜	1¾	2⅛	2⅛	1⅝	1¾	2	1¼	1¾	2
Diameter of exhaust valve, in.	1½	1¾	2⅜	1¼	2⅛	2⅛	1⅝	1½	2	1⅝	2	2¼
Compression ratio	4.5	4.45	4.25	4.42	4.13	3.9	4.5	5.46	4.4	4.5	5.54	4.2
Spark advance, deg.	8.25	8.6	20.8	24.6	15.6	20.7	18	16.4	20.1	18	19.6	15.2
Exhaust opens—deg. early	30.4	32.2	26.9	34.6	28	34.8	25.6	32.4	34.8	25	33	20.5
Exhaust closes—deg. late, or on center (C)	11.9	C	C	C	C	C	C	C	C	C	C	C
Ignition—make and break (M & B), jump spark (JS.)	M & B	M & B	M & B	M & B	M & B	M & B	J.S.	J.S.	M & B	M & B	M & B	M & B
Ignition source, battery (B), magneto (M)	B	B	B	M	M	M	B	B	B	B	B	B
Carburetor, pump feed (P.F.) gravity feed (GF.) suction feed (SF.)	PF	PF	PF	GF	GF	GF	SF	SF	PF	PF	PF	PF

All the engines were hit-and-miss governed, and all except No. 1 were nopper cooled; No. 1 had a circulating system.

The length of time required for the individual tests varied, with one exception, from two to three hours. The length of time for each test depended upon the time required to bring the fuel consumption approximately constant, this time varying from 15 to 45 min. The tests were, therefore, made of such length as to give two hours of consecutive running under favorable conditions.

Table 2 gives the summaries of the computations of the original data. In securing these summaries, only the last two hours of the individual tests were used.

The cost of fuel per brake horsepower-hour is estimated on the basis of gasoline costing 16c. per gal.

Irregularities in Data

The data given under description for engine No. 1 show that the spark was not advanced as far as in the other engines. This engine also ran above the rated revolutions per minute, which accounts for the relatively large horsepower it developed.

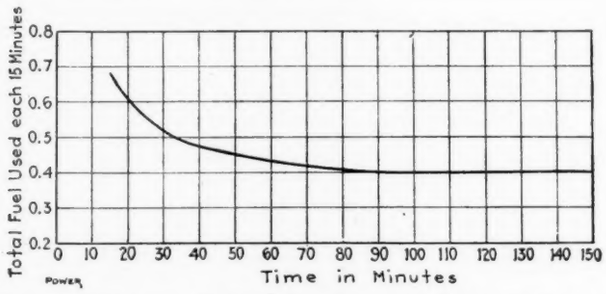


Fig. 1. Showing Time Required for Fuel to Become Constant

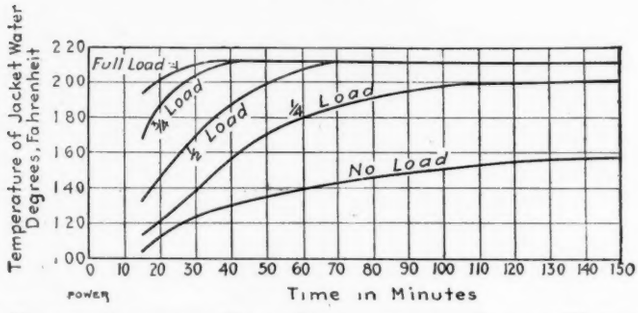


Fig. 2. Showing Time Required for Jacket-Water Temperature to Become Constant

The data given in the fifth test for engine No. 12 represents a one-hour run. In all maximum-load tests, the pounding became so excessive that although four trials were made the test could not be run to completion.

Conclusions

So much time was required for running the individual tests that it is important to find out at what point the fuel consumption becomes constant. The fuel consumption is plotted against time in minutes and is shown in Fig. 1 for the no-load test. This shows that the fuel consumption became practically constant in 90 min.

The fuel consumption for the quarter-load tests showed a tendency to become constant after 75 min., and for one-half load after 60 min.; the fuel consumption for three-quarter load was constant after 45 min., and for the maximum load after 15 min. These results indicate that the lighter the load, the longer it takes the fuel consumption to become constant.

The curves plotted in Fig. 2 show the time required for the temperature of the jacket water for the various loads to become constant. The average temperatures of the jacket water for all the engines under the various loads are taken at fifteen-minute periods.

Table 3 gives a comparison of the time required for the fuel consumption and temperature to become constant for the different loads.

This shows that the fuel consumption becomes constant before the temperature of the jacket water, which would indicate that if some means were employed to heat the water in the jacket, the length of the tests could be materially shortened without affecting the accuracy of the data.

TABLE III

Load	Time at which fuel consumption became constant	Time at which temperature of jacket became constant
None	90 min.	150 min.
¼	90 min.	105 min.
½	60 min.	75 min.
¾	45 min.	45 min.
Maximum	15 min.	45 min.

Fig. 3 shows the fuel consumption in pounds per horsepower-hour plotted against the different loads for the three general classes of engines. These values were found by taking an average of the separate fuel consumptions for all the engines in the class at the given load.

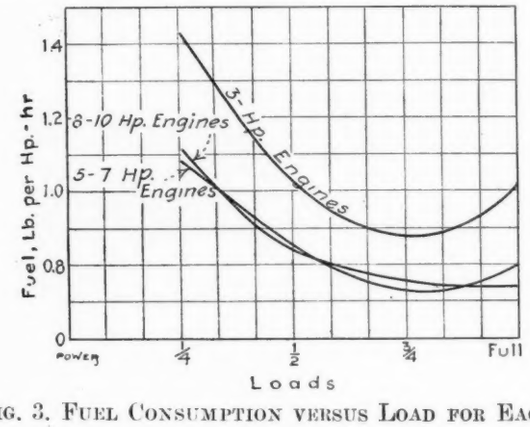


Fig. 3. Fuel Consumption versus Load for Each Class

The curves show that for the 3- and 5- to 7-hp. engines the greatest fuel economy is at the three-quarter load, while for the 8- to 10-hp. engines the greatest economy was secured at the maximum loads. This discrepancy may be explained by the fact that the true maximum loads of the larger engines were not reached in the tests.

It is reasonable to assume that it takes the same amount of fuel to carry the friction load of the engine without regard to the horsepower being developed. If this is the chief factor in determining the fuel economy at different loads then if no other factors enter, the greater the load carried the less will be the fuel used per brake horsepower hour. In order to study this the curves in Fig. 4 were plotted. Here the pounds of fuel per horsepower-hour are obtained for each class of engines by subtracting the total fuel used in the no-load tests from the total fuel consumed in the test for the one-quarter, one-half, three-quarter and maximum loads.

These curves tend to show that up to three-quarter load the friction load of the engine is the chief factor in determining the fuel economy. The 3-hp. and 5- to 7-hp. classes show that from three-quarter to maximum

load other factors enter which cause a very rapid increase in the fuel consumption per horsepower-hour, while the 10-hp. class shows little increase. This would be expected as these larger engines did not reach their maximum horsepower. The smaller engines when running at maximum loads in most cases developed pounding in the cylinder not noticeable at other loads, which point bears out the general conclusions shown from the curves that at maximum loads new factors (probably due to

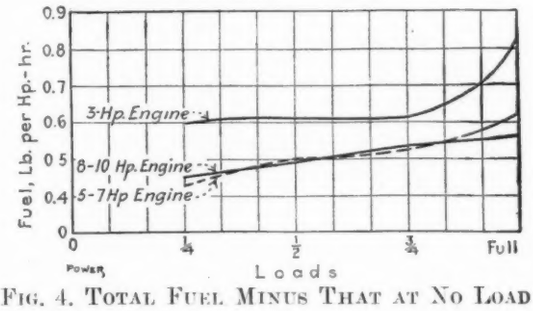


FIG. 4. TOTAL FUEL MINUS THAT AT NO LOAD

excessive heat in the cylinder) enter to increase the fuel consumption.

ECONOMICAL SIZE FOR GIVEN HORSEPOWER

The curves in Fig. 5 indicate the proper size of engine to select in so far as fuel consumption is concerned. In these curves, the fuel consumed per horsepower-hour is plotted against the horsepower developed for the three classes of engines, having an average piston displacement of 55.7, 90.4 and 125.4 ft. per min., which corresponds to the 3-, 6- and 10-hp. classes as previously used. The basis of division according to piston displacement is somewhat nearer an absolute classification than the rated horsepower. These curves show that from 1.7 to 3 hp. the engines having a piston displacement of 90.4 cu.ft. per min. are just as economical as those having a piston displacement of 55.7 cu.ft. per min., and that the larger

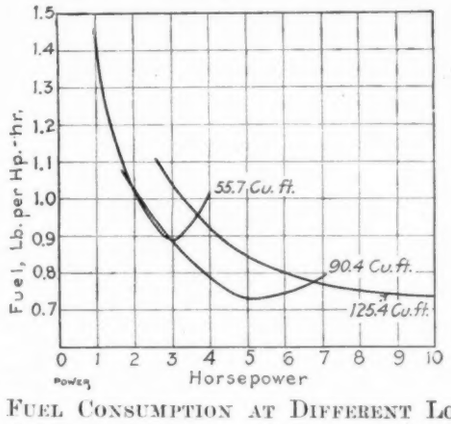


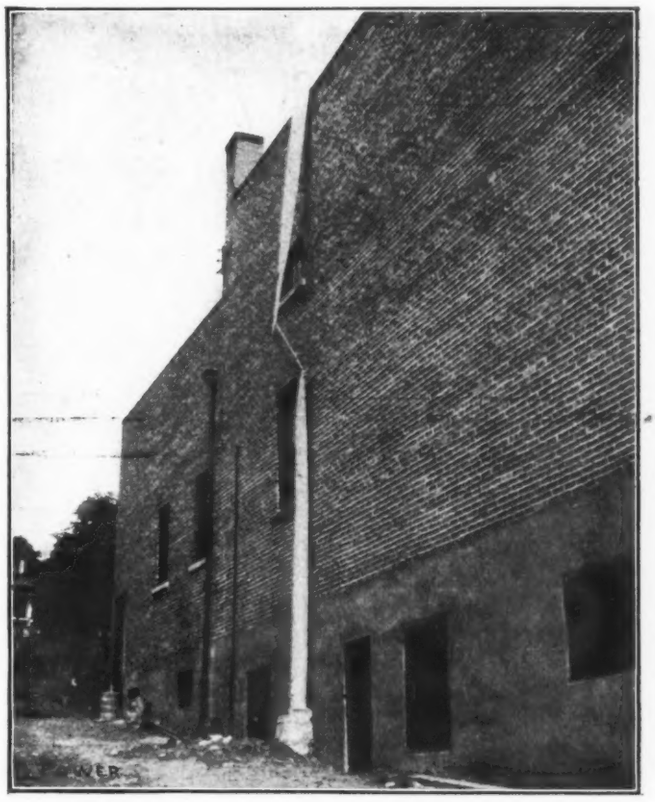
FIG. 5. FUEL CONSUMPTION AT DIFFERENT LOADS FOR DIFFERENT CYLINDER DISPLACEMENTS

displacement is more economical from 3 to 4 hp. From 4 to 6.75 hp., the engines having an average displacement of 90.45 cu.ft. per min. are more economical than those having a displacement of 125.4 cu.ft. per min., and from 6.75 to 10 hp. The larger displacement gives the most economical results.

From the foregoing it may be concluded that from 1 to 6.75 hp. the engine having a displacement of 90.4 cu.ft. per min. corresponding to a rated 6-hp. engine is, in so far as economy in fuel consumption is concerned, the most desirable engine. This eliminates those engines having an average piston displacement of 55.7 cu.ft. per min., corresponding to 3 hp. For horsepowers above 6.75, the engines having a piston displacement of 125.4 cu.ft., or the 10-hp. engine, would be the most desirable.

Explosion in Muffling Chamber

A rather unsual accident occurred recently at the Seattle Engineering School, Seattle, Wash. In their gas-engineering laboratory seven or eight gas engines are piped into a common exhaust line, which leads into a muffler just outside the building. This muffler is a concrete chamber five feet wide, nine feet long and four feet



EXHAUST PIPE AFTER EXPLOSION

deep. The entire chamber is under ground. At one end of this muffling chamber is a 10-in. galvanized-iron stack about 35 ft. long for carrying off the exhaust gases; this extends to the roof of the laboratory.

At the time of the explosion the only engine running was a 48-hp. four-cylinder Cadillac automobile engine. In testing out the ignition system students tried to run the engine on each cylinder alone, holding down the induction-coil vibrators of three cylinders. This operation was continued for some time before the instructor knew just what was going on, being busy elsewhere. All the gas which was not being burnt was, of course, being exhausted into the muffling chamber. Finally enough had collected there to cause a violent explosion. Although the explosion gave no violent report, it split the walls of the muffling chamber in a number of places and also the concrete pedestal supporting the stack. What happened to the stack is shown by the accompanying illustration.

GEO. W. MUENCH.

HEATING AND VENTILATION

Operating Economics in Heating Large Factory Buildings

In a paper read before the National District Heating Association at Indianapolis, Edward L. Wilder showed how the Rochester Ry. & Light Co. had been able to effect economy in the operation of the heating systems of two of its large customers. In these particular cases, intermittent heating gave better results than a continuous supply of steam, but the conditions were not equally favorable for both methods. The discussion following the paper favored continuous heating, especially when the outside temperature was below 30 deg. F.

The first case was that of a factory used for the manufacture of automobiles. It is a well constructed brick building, four stories high, and having a total floor area of approximately 60,000 sq.ft. All the heating is done by direct radiation. The installation of a recording thermometer showed that the steam was left on the building all the time, and there was a decided rise in temperature during the night hours. Upon recommendation care was taken to see that at the end of the working day all windows were closed and the steam entirely shut off, turning the steam on in the morning in time to make the factory comfortably warm at 7 o'clock.

Fig. 1 shows a typical week's record of the recording thermometer, taken after the recommendations had been put into effect. It may be noticed that the temperature falls off gradually during the night hours and on Sunday and readily responds when the steam is turned on about 6 o'clock in the morning. The temperatures of 70 deg. and over shown during the afternoons were unnecessarily high for a machine shop. This is accounted for by the fact that the thermometer is placed in the center of the room, and the temperatures near the windows were probably somewhat lower than recorded. In general, the present operation of the system is satisfactory. The temperature record is for the week commencing Saturday, Jan. 18, 1913, and the outside temperatures as recorded by the weather bureau, are as follows:

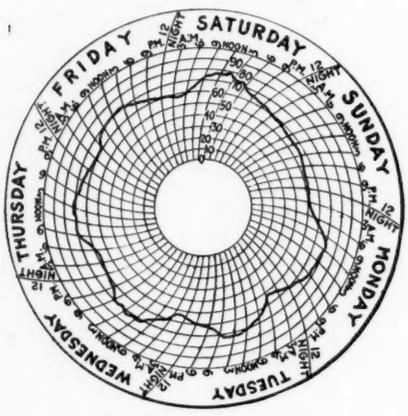


Fig. 1. Typical Week's Temperature Record

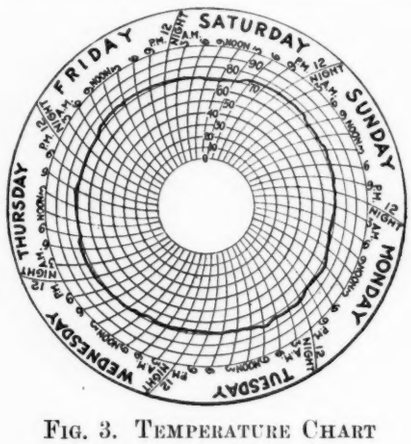


Fig. 3. Temperature Chart Taken before Schedule Was Put in Force

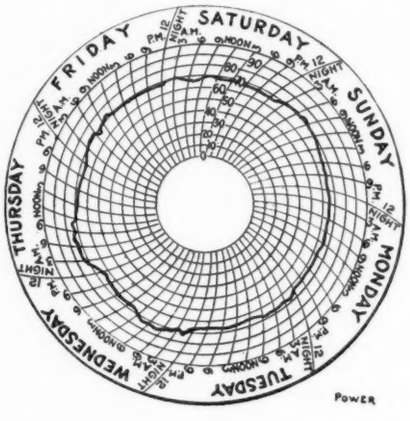


Fig. 4. Chart When Operating on Schedule

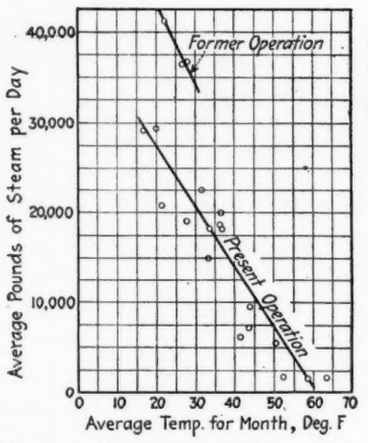


Fig. 2. Economy of Intermittent Service

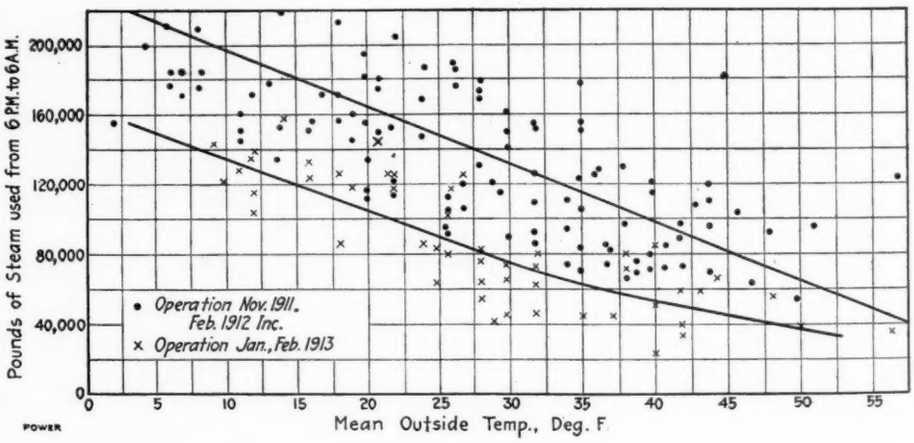


Fig. 5. Steam Used for Night Heating

	Maximum	Minimum	Mean
Saturday	51	30	40
Sunday	35	29	32
Monday	55	33	44
Tuesday	33	23	28
Wednesday	36	25	30
Thursday	47	30	38
Friday	39	31	35

To show the effect on the total steam used for heating, the pounds of steam used per day were averaged for a number of months, and plotted against the average outside temperature for the same months. The results are shown in Fig. 2. The lower curve covers a period of over two years and indicates an average saving of 37 per cent.

The second case was a group of factory buildings with a ground area of approximately 75,000 sq.ft. All the buildings are of good brick construction varying in height from five to seven stories. The heating is mainly by the fan system, and there is provision made for recirculating the air in only one of the buildings, which forms approximately one-quarter of the total heating load. Preliminary investigation showed that the steam was left on the heating coils all the time, that the cold-air openings were not closed at night, and that, if the weather was at all severe, the fans were run continuously. The installation of recording thermometers in several places showed that the night temperatures often ran up to 80 deg. and over. Several tests were run on the operation of the system during the night hours, and the following facts were developed.

With the cold-air openings closed and the steam entirely shut off, the temperature in the buildings dropped at a rate of approximately 1 deg. per hour in severe weather. When the steam was turned on the coils but the fan not started, the natural circulation would hold the temperature approximately constant. When the fans were started up, the temperature of the buildings responded rather slowly.

The conditions of this establishment are entirely different from those in the first one described. In the first factory the work requires considerable muscular exertion, and if the temperature is a little low in the morning, no particular harm is done. In the second case, a great deal of the labor is light bench work, a great many girls are employed in certain departments, and some of the work in progress would be ruined if the temperature were allowed to get too low. It was the opinion of the management that the temperature should not be allowed to get much below 65 deg. at any time, and that 70 deg. was the desirable temperature during the working hours.

Based on the data given above, the following schedule for the operation of the heating system was recommended.

GENERAL INSTRUCTIONS

5:30 p.m. Close cold-air intake, stop all fans, turn off steam from all fan coils.

6 a.m. Open cold-air intakes. Amount of opening to be regulated by condition of temperature and wind pressure outside. If temperature in any building gets below 65 deg., steam must be turned on and fans started in such building immediately.

IF OUTSIDE TEMPERATURE IS ABOVE 45 DEG.

4 a.m. Turn steam on fan coils.

6 a.m. Start fans taking air from basement, except in Building 7.

IF OUTSIDE TEMPERATURE IS BETWEEN 35 AND 45 DEG.

3 a.m. Turn steam on coil fans.

4 a.m. Start fans.

IF OUTSIDE TEMPERATURE IS BETWEEN 25 AND 35 DEG.

6 p.m. Turn steam on coil fans.

3 a.m. Start fans.

IF TEMPERATURE IS BELOW 25 DEG.

6 p.m. Turn steam on coil fans.

1 a.m. Start fans.

Fig. 3 shows a chart from the recording thermometer taken before this schedule was put in force, and Fig. 4 shows a record from the same thermometer afterward. Fig. 3 shows an operation rather better than the average and Fig. 4 shows in a lesser degree the same "sawtooth" effect secured in the first factory described. Following are the outside temperatures for the week of the chart shown in Fig. 4:

	Maximum	Minimum	Mean
Sunday	35	29	32
Monday	55	33	44
Tuesday	33	23	28
Wednesday	36	25	30
Thursday	47	30	38
Friday	39	31	35
Saturday	51	30	40

To determine what economy had been effected, the steam used during the night hours was plotted against the corresponding outside temperature in Fig. 5. The solid dots show the old method of operation, and the crosses show the results obtained after the recommendations were in force. The curves drawn give the average of these points. The total steam used for heating showed an average decrease of 32 per cent.

Loss Caused by Elbows in Air Ducts*

It has been shown by different experimenters that the loss in pressure in heating and ventilating systems through a sharp-turn elbow is the greatest, and that this loss gradually decreases as the radius of curvature of the elbow is increased. In the present paper the results of a series of experiments carried on at the testing plant of the Buffalo Forge Co. are given. Two sets of experiments were carried on: the first to determine the effect obtained by changing the radius of the elbow; the second to study the effect of reducing the throat of the elbow to the theoretical or blast area.

The general arrangement of the apparatus used in making these experiments is shown in Fig. 1. It comprised a blower equipped with an arrangement for varying the air quantity—an air-tight box into which the air

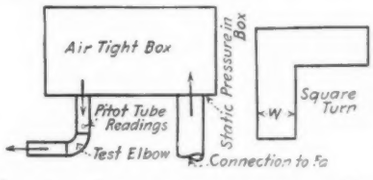


FIG. 1. ARRANGEMENT OF TESTING APPARATUS

FIG. 2. TYPES OF ELBOW USED IN TESTS

is blown—and an outlet from the box so arranged that the different elbows or fittings may be attached and their effect studied. The discharge outlet was fitted with a short length of pipe three diameters long, and a pitot tube mounted in the center of the pipe one diameter from the outlet. The elbows were attached to the outlet end of this short pipe and another piece of pipe three diameters in length placed on the outlet end of the elbow.

*From a paper read by Frank L. Busey before the American Society of Heating and Ventilating Engineers, July 17-19, Buffalo, N. Y.

In making these experiments the static pressure in the box was accurately measured and by means of a sensitive differential gage attached to a pitot tube in the short outlet pipe the velocity pressure of the air in the outlet was also noted. As different elbows were attached to the outlet pipe, the speed of the fan was increased so as to maintain a constant-pressure reading at the pitot tube. The static pressure in the box increased and the increase noted as a measure of the resistance or pressure loss of the elbows used.

Careful tests were made to determine the coefficient of the short length of pipe attached to the outlet of the box, and 0.825 selected. That is, the actual velocity through the pipe or the effective area of the pipe will be only 82.5 per cent. of that indicated. The velocity head producing the discharge will then be the static pressure reading in the box multiplied by the square of 0.825. Any increase in static pressure due to the addition of an elbow to the outlet expressed as a percentage of the velocity head as determined in the foregoing gives a direct measure of the pressure loss due to this especial elbow as a percentage of the velocity head. Quite an extensive series of experiments were made with various static pressures and rates of discharge.

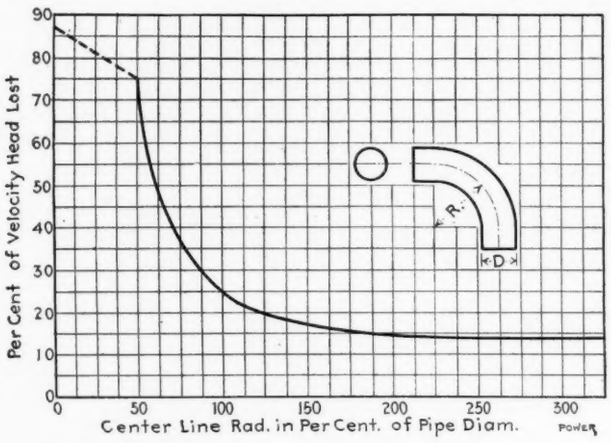


FIG. 3. PRESSURE LOSS IN ROUND ELBOWS

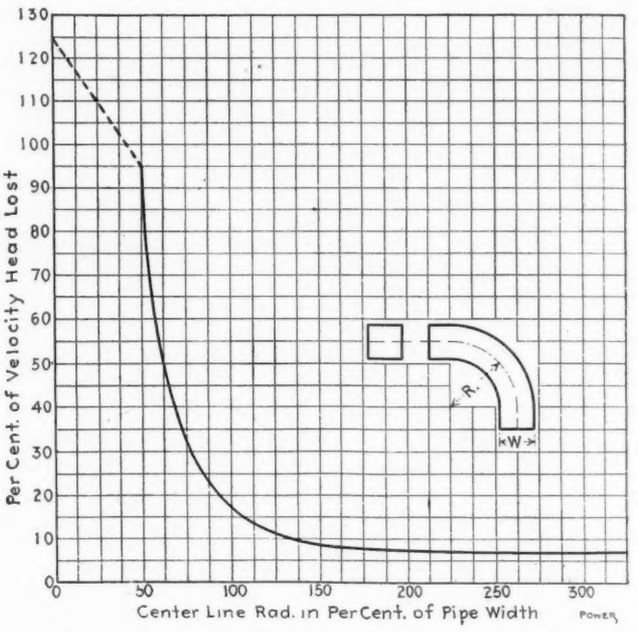


FIG. 4. PRESSURE LOSS IN SQUARE ELBOWS

PRESSURE LOSSES DUE TO ELBOWS

The character of the elbows used in these experiments is shown in Fig. 2. They were either round, 12 in. in diameter, or square, 12x12 in. in section, elbows of similar radius of curvature being tested in both the round and square sections. What is here termed a square-turn elbow is shown in Fig. 2 as being actually of a square or two-piece type. The term short-bend elbows is used to designate those elbows having the outer surface rounded off and the inner angle either square or sprung to a very short radius. The easy-bend elbows were those having a center-line radius of from one to three times the pipe width or diameter. Nine elbows, each of the round and square section, were used, as follows:

R = Center-Line Radius In Diameters	R = Center-Line Radius In Inches	r = Throat Radius Inches
0.50	6	0
0.75	9	3
1.00	12	6
1.25	15	9
1.50	18	12
2.00	24	18
2.50	30	24
3.00	36	30

The curves in Figs. 3 and 4, based on actual test results, show respectively the loss by friction through elbows of either round or square section. The loss in per cent. of velocity head is given for elbows of different radii, the center-line radius being expressed as a percentage of the pipe diameter or width.

It may be seen from these diagrams that with $R = 1\frac{1}{2}\ D$, or an inside radius of one diameter, fairly good results may be obtained, without making the elbow unduly long. Practically nothing is gained by making the radius R greater than $2\ D$.

It is also evident from an inspection of these diagrams that if it can possibly be avoided an elbow with R less than one D should not be used. Even with $R = D$ an elbow in a square duct will cause a loss of 17.5 per cent., and in a round duct 25.5 per cent. of the velocity head. In case $R = \frac{1}{2}\ D$ (throat of elbow square, but outer side rounded to a radius of one diameter) the loss in a square duct will be approximately one, and in a round duct three-quarters of the velocity head. The loss indicated on the diagram for $R = O$, represents tests on elbows of two-piece construction, or with both inside and outside made square.

From the curve for the round ducts it will be seen that with an elbow having $R = \frac{1}{2}\ D$ the loss will be 17 per cent. of the velocity head. If it is considered that one velocity head is lost in 50 diameters of straight pipe, this means that this elbow is equivalent in friction effect to 8.5 diameters of pipe. If the elbow were in a square duct the loss would be equal to 4.5 diameters (or widths) of pipe with a velocity of 2000 ft. per min. through the duct, corresponding to 0.25-in. pressure, or a velocity head of 0.25 in., the foregoing elbow in the round pipe would cause a loss of 0.0425 in. and in the square ducts of 0.0225 in.

For ordinary calculations one easy long-radius eblow in a circular pipe may be considered as equal in friction loss to 10 diameters of straight pipe. The results of the tests to determine the effect of reducing the throat of the elbow to the theoretical or blast area will be given in a later issue.

EDITORIALS

The Hall of Records Test

The test now being conducted at the Hall of Records is attracting wide attention, not only because it is probably the most comprehensive ever undertaken, but also because of the bearing the results are likely to have upon the future policy of the city relating to operation of power plants in public buildings.

Many have criticized the city for entering into partnership with the New York Edison Company in the solution of a problem of this character. While there may have been mitigating circumstances to excuse such a course, from the viewpoint of an outsider the criticisms seem justified. Certainly New York City could afford the costs of such a test and has enough engineering talent in its employ, without taking into its counsels a private party whose interests are decidedly partisan and whose actions are bound to be governed accordingly.

We do not mean to infer that this is likely to have any influence upon the actual test, which, we are satisfied, is being conducted along strictly impartial lines; but it does give the New York Edison Company a large representation in the advisory board which will determine the overhead charges. Judging from past experiences, the representatives of the Edison Company will undoubtedly try very hard to burden the plant with all sorts of fictitious fixed charges, and it behooves the other members of the board to take a determined stand against any such attempts.

If it were a question of shutting down the plant and substituting central-station service, then only fixed charges upon its scrap value should be considered. But where it is desired to arrive at the total cost of producing electrical energy then all the proper charges should be included, but no more.

In the first place the Hall of Records plant cost much more than it should, as a result of which the legitimate fixed charges will necessarily be high. Moreover, the plant is underloaded. In apportioning the fixed charges the electrical load should be charged with only its share of the steam-making equipment in the proportion of its load to the total load on the plant.

No doubt an attempt will be made to charge rent for the floor space occupied by the plant. We do not believe, under the circumstances, such an item should be allowed, but if it is, the rate should be based solely upon what the city could get for this space in the sub-basement were it to rent for storage purposes.

The policy of making public no figures until the test is completed, is commendable. Of course, this does not apply to the New York Edison Company which receives duplicate copies of all data—a privilege to be expected in return for its contribution toward defraying the expenses of the test; but even though the final outcome be unfavorable to its interests, the money will have been well spent in securing complete data which the company may use for reference in other cases that may come up from time to time.

The Smoke Inspector's Tribulations

As noted on another page a fine mess of petty crime has been unearthed in the smoke-inspection department of the City of Chicago through the suspension of nine deputy inspectors and their trial before the city Civil Service Commission.

Chicago's smoke-inspection department is probably more widely and favorably known than any other in the United States. The reasons for this are because it was among the first to be instituted and, principally, because it has accomplished much, both along the line of actual smoke abatement in that city and in solving the engineering problems encountered in attempts to secure smokeless combustion. Almost all cities of any size now have their smoke-abatement departments and the work of educating the plant owner and operator to an appreciation of the advantages, both direct and indirect, of smokeless operation has now progressed very materially.

The present trouble in Chicago, however, serves as a reminder of the generally unpleasant nature of the chief inspector's task.

The tendency of the general public is to fasten the eye of suspicion upon him unless he succeeds, instantly upon appointment to office, in eliminating all smoke within the city gates. The public seldom considers that he has a thousand and one obstacles confronting him, many of which are almost insurmountable. Often, the money appropriated for the use of his department is inadequate and he cannot employ the amount and grade of assistance needed for best results. The secret corruption of his subordinates is another factor that is ever imminent. Imminent because, as yet, it is only the strength of the individual that prevents its development. If the present situation in Chicago is any criterion, the plant owner and operator, principally the owner, we are inclined to believe, from the evidence in hand, consider that bribery is more economical than reasonable effort toward smoke prevention. In reality, it is doubly expensive, because the inefficiency manifested by the presence of smoke endures while the value of the bribe constitutes an added loss.

On the other hand, the plant owner or operator, if he be too shrewd or virtuous to stoop to bribery, is ever ready to believe that the head of the smoke department is a rogue, if he is prosecuted for smoke-ordinance violation. He is convinced that his offence is no more flagrant than that of his neighbor, who has offended unmolested. Occasionally he is correct, if his neighbor happens to be one of the bribe givers. More often, he is mistaken—the offenses of our neighbors loom large compared with our own.

Finally, the head of the smoke department is often the victim of political conspiracy. If the party in power changes he has the prospect of being required to look elsewhere for occupation. Always, he may expect to enjoy the efforts of detractors in the form of disappointed aspirants to his position.

The Penalties of Boiler Mismanagement

The importance of good firing can never be exaggerated in studying steam-plant economy. The evil results of improper fuel handling, of poor water tending and of a parsimonious policy in the boiler-room wage account bring so much discredit upon executive officers responsible for such conditions that a larger knowledge of just what happens when the steam generating end of an installation is neglected is most desirable.

Not many weeks ago a series of tests was made of a 10,000-ton steam turbine passenger vessel guaranteed by the builders to make sixteen knots per hour when operated intelligently on Cumberland coal or its equivalent, with a maximum fuel consumption of seven tons per hour. The boat was equipped with ten water-tube boilers and was propelled by two marine turbines rated at about 4000 horsepower each. She was the product of one of the best American shipyards, and yet she failed to meet the above guarantee on the service trials, although on preliminary trials by her builders she met the requirements in first-class fashion. What was the reason for the trouble?

A careful study of the conditions obtaining on the service trials brought to light an amazing neglect on the part of the vessel's purchasers of the methods of proper steam engineering in the operation of the boat, and in a word, almost every trouble encountered was found to be due to poor firing and associated difficulties. The vessel's builders warned the purchasers that water-tube boilers called for much more skilful firing than the usual Scotch marine boilers, including a more even distribution of coal over a larger grate area and particularly a close control of the water level. The boilers used contained only about one-fourth as much water as the Scotch marine units first suggested. By the use of water-tube outfits about twenty thousand dollars was saved in the construction of the ship, and better deck arrangements and coal distribution of an improved character were secured. The purchasers contended that their engineers were thoroughly alive to the situation and at once set about the service tests.

On the vessel there were three sets of firemen required, with three shifts of water tenders, the watches being four hours in length. The purchasers desired to operate the vessel with a total of twenty-four firemen, or eight per watch, and with one water tender per watch; while the builders maintained that thirty firemen were necessary to operate the ship at its contract speed, and that two water tenders per watch should be provided in view of the type of boilers used and the fact that half the boilers were in one boiler room and half in another. The latter arrangement was utilized on the builders' preliminary trials, when the vessel met her contract requirements, but on the service test only twenty-four firemen and three water tenders were used, with the additional disadvantage that none of the former had had experience in firing water-tube units. This arrangement, instead of providing one fireman per boiler and making four fire doors the number to be cared for by each man, made it necessary for each fireman to serve five doors. The firing in adjacent boilers was thus overlapped, and there was established a sort of dead line in the fire between each man's assigned grate areas which resulted in serious inefficiency of combustion and reduced capacity in steam raising.

The inexperience of the force and its inadequacy in point of numbers led to excessive coal consumption, water going over into the turbines, and to priming. On the builders' tests, when the equipment was given a fair show, the fuel consumption per brake horsepower-hour was about 2.2 pounds, the speed of the vessel being 16.7 knots. On the service trials, when the reduced number of firemen and water tenders was employed, the coal consumption rose to 4.14 pounds per brake horsepower-hour, and the speed of the ship seldom exceeded 14 knots. Instead of maintaining an even water level, there were observed the most serious fluctuations in the height of the water in individual boilers, both above and below normal. No automatic regulators controlling the feed-water supply were installed until a later period. The steam pressure varied all the way from a normal of 250 pounds at the boilers to 180 pounds; the firing was extremely irregular, holes were allowed to accumulate at various points on the grates and the draft was poor as a result. The coal was laid on the fire in lumps and hollows, dead areas were permitted to accumulate on the rear of the grates, and the fuel was not spread as it was fired, but was thrown into the furnaces in bulk. As the steam pressure dropped, strenuous efforts were made to choke the furnaces with enough fuel to overcome the fall.

On account of overfilling the boilers with water, it became necessary many times in the early runs to blow them off, so that more than 300 tons of the fresh water feed supply used in the closed condensing system and boiler tubes was lost in the first run, necessitating pumping salt water into the feed tanks near the end of the test voyage and later requiring the introduction of muddy river water for the same service.

The going over of water to the turbines due to excessive water level slowed down their speed from 10 to 20 revolutions per minute, the water lowering the steam temperature and acting as a mechanical brake in the spaces between the blading. With the introduction of the salt feed and of the muddy river water into the boilers excessive wear almost immediately developed in the turbines and their auxiliary pumps. Priming also occurred at the boilers, and trouble occurred through the seizing of the air pumps, with consequent loss of vacuum and of efficiency. The turbine blades were built of extruded bronze, but were eroded as though they had been subjected to a sand blast. The use of water charged with mud fouled the air-pump buckets and resulted in serious scoring and marring of pistons, rods and valves. Water entering the steam cylinders of the pumps short-stroked these, and the equipment as a whole was damaged to an extent requiring the expenditure of many thousands of dollars in repairs.

Taken as a whole the tests bear eloquent testimony to the need of adequate supervision and discipline in the boiler room, to the importance of maintaining regular conditions in firing and water tending, particularly in the number of men employed, and above all they emphasize the penny-wise-and-pound-foolish economies of cutting down the boiler-room payroll to a point where skilled men cannot be obtained for the difficult and responsible work of firing.

READERS WITH SOMETHING TO SAY

Corliss Valve Trouble

Our 1000-hp. Corliss engine, slowed down, refusing to carry the load. The eccentrics are marked and inspection proved them to be properly adjusted. On again starting, the receiver pressure went considerably above normal, and in turning the regulating rod to reduce it we found it further increased. To reduce it we had to turn the rod in the opposite direction.

This directed our attention to the admission valves of the low-pressure cylinder. The valves are in a vertical position. The setscrew, which prevents the valve stem from turning, was found loose, allowing the rod to turn, which lowered the valve until it took steam over the top. When the valve was raised it closed the ports, shutting off the steam.

The valve was raised and properly set by use of the indicator.

North Adams, Mass. JAMES MITCHELL.

A Few Interesting Kinks

Every engineer knows how bothersome it is to protect blowoff pipes inside the boiler setting. I have found a new way to protect mine. Instead of bothering with cast-iron sleeves that seldom fit or brick covers that split and fall down, to say nothing of filling the space in the combustion chamber, I simply cover the blowoff pipe from the boiler to the wall with ⅞-in. asbestos rope. Then I make a plaster of equal parts of asbestos meal and fire clay and add one pint of fine salt to a 16-quart pail full of the plaster, and add just enough water to make a stiff mass. This is plastered on over the rope with the hands and crowded between the turns of rope.

Perhaps some of the readers of POWER have had occasion to temporarily connect a fire hose to a steam-pipe line at some time or other and found trouble in getting a fitting that would make the connection. I used to have a lot of trouble myself until I found this kink: Take the male-thread end of a discarded length of 2½-in. fire hose and cut or burn off the canvas and rubber. Then find a piece of 2-in. pipe with a thread on one end and file the other up brightly for about 2½ in. of its length and either insert the pipe into the hose coupling and solder it there or do a real good job by tinning the pipe and sweating or brazing it into the hose fitting.

A few weeks ago I had a night fireman who was careless about blowing down the boilers and as a result I found a plugged blowoff pipe, so instead of taking all the joints apart clear back to the boiler, I simply disconnected the pipe back to the blowoff cock, and then, taking the fitting described above, screwed it into the cock and connected a length of hose from it to the fire pump. I then started the fire pump slowly and opened the cock. This quickly removed the scale from the boiler.

Auburn, Mass. W. E. CHANDLER.

Corrosion and Erosion

The writer has, on several occasions, seen articles describing, and illustrations showing, various pump parts badly eaten by the action of the water, the cause of which was almost always attributed to electrolysis.

In a recent article pictures were shown of a pump runner and diffusion vanes which had been badly eaten by the water. It was noted that the motor current consumption increased as the wearing increased, and the supposition was that some of the current leaked out and set up an electrolytic action and so damaged the pump. The water handled by the pump contained some salt and sulphur.

The writer has had some experience with pump failures of this nature and believes that the cause of the damage in this case was not due to electrolysis, but to the combined action of corrosion and erosion, mostly the latter.

Erosion is due to the mechanical action of the water striking continually on a metal surface and its effect is sometimes very rapid. This action must be distinguished from corrosion, which is a purely chemical action. The effects are most marked when operating under high speed or with water containing harmful chemicals or grit.

Experiments have been made with various metals at the concern where I am employed, and the action of water on them has been studied. Cast iron was originally used for making pump runners, but when turbine-driven the pumps proved short-lived when handling even the purest water. For slow-speed, motor-driven pumps, running from 480 to 720 r.p.m., the erosive effect was not nearly so bad.

The practical metals best suited to resist the action of erosion may be listed in the following: Monel metal, hydraulic bronze, acid-resisting bronze, phosphor bronze, chilled cast iron, cast iron and lead.

The action of the water on the metal is both mechanical and chemical. Most of the wear is caused by the action of continuous hammering of the water on the metal. This is also accomplished by more or less chemical action, depending on the character of the water.

Water in striking the metal makes innumerable small holes, giving the metal the appearance of worm-eaten wood. In some cases the erosion was so bad that the metal was similar to chalk or paste in character. The rapidity with which this change takes place is almost unbelievable.

A brass diffusion vane, by mistake, was placed in a pump backwards. The metal in the vane was about ½ in. thick. This was worn through by the action of the water in about 60 hr. This is, of course, much faster than could be produced by chemical action alone. The water velocity leaving the wheel in this case was something like 90 ft. per sec.

Lead is one of the very best metals to resist corrosion, but it is very poor in resisting erosion. One of the necessary qualities to resist erosion is that the metal have a very hard, smooth surface.

Copper is much too soft to resist the eroding action of water traveling at high velocity, but it is very well suited to withstand the eroding action of steam, unless the steam is highly superheated.

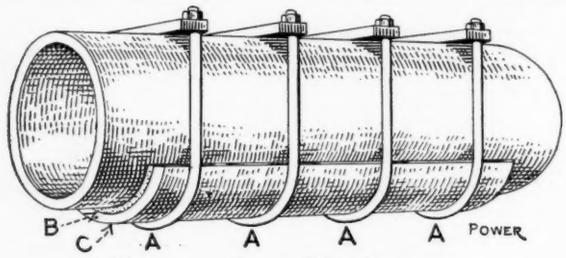
When a pump runner or diffusion vanes become seriously eroded the pump efficiency becomes low and requires more than the normal power to operate it. This would account for an increase in power required and is a more reasonable explanation for the increased power consumption, mentioned, than the supposition that some of the current leaked out and set up an electrolytic action.

HAROLD M. GRAHAM.

Wilkinsburg, Penn.

Stopping a Bad Leak

The 4-in. suction pipe leading from a pond to a circulating pump froze and burst. As there was no union near the fracture, to put in a new length of pipe would mean to take up the pipe from the pond to the fracture.



HOW THE LEAK WAS STOPPED

The illustration shows how it was repaired. *AAAA* are U-bolts, *B* is a gasket and *C* is a piece cut from a pipe of slightly larger diameter than the pipe to be repaired.

EARL PAGETT.

Coffeyville, Kan.

More about Graphite for Boilers

For a period of ten weeks I have been experimenting with graphite as a scale remover, and find that it proves satisfactory in our boilers. As the action of the graphite is very slow, various boiler compounds have been mixed with it, the idea being to soften the scale a little quicker and allow the graphite to get to the plates sooner. After three trials in which careful observations were made, the best results were found to be obtained when using a mixture composed of half a pound of graphite mixed with one pound of soda ash and feeding the mixture at the rate of one pound of mixture to each 20,000 lb. of water. This mixture should, undoubtedly, vary with the nature of the feed water and working conditions, the mixture is fed in along with the feed water and feeds constantly through an ordinary composition feeder, the ash and graphite being first mixed dry and put into the feeder.

On closely examining scale which has come away of its own accord, the surface which has been next to the shell will be seen to be dotted with graphite specks, these will be quite clear under a good glass. It has been our experience that practically no scale forms where the old has come off when graphite has been used.

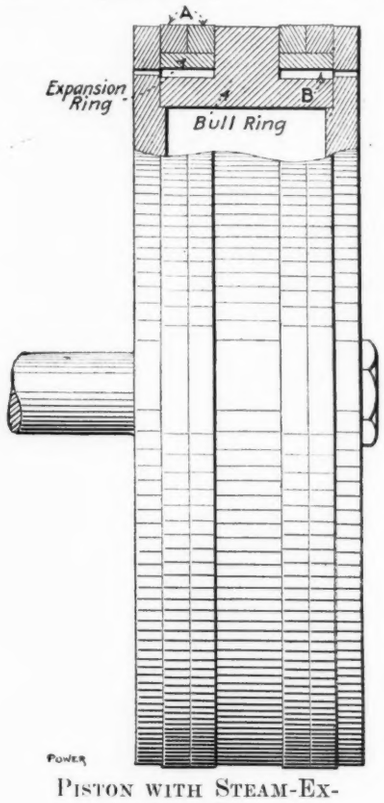
The action of graphite in removing scale is not clear, but it certainly removes the scale, and I am under the impression that if one were to well rub the plates of a new boiler with graphite and water or some other moistening medium, no trouble would be experienced from scale. It would be interesting to all engineers if someone who has a new boiler going in service would try the experiment and publish the results in POWER.

The writer is shortly going to try graphite in one plant that is badly scaled, and as many chemical works and other factories use the water before it comes to this mill, compounds have all failed, the feed not being of the same composition three hours a day. The only way to use this water is to allow the boilers to scale so as to protect the plate from the corrosive water. The scale is now so heavy as to subject the boiler to bagging at high pressures and temperatures.

Rochdale, Eng. E. R. PEARCE.

Steam-Expanded Piston Rings

The accompanying illustration shows a piston with steam-expanded rings which has recently been patented by H. Gulbranson, of Mason City, Iowa. As will be seen, there are two piston rings *A* which fit snugly over



PISTON WITH STEAM-EXPANDED RING

an expansion ring and two of these combinations are slipped over a bull ring which is $\frac{3}{16}$ in. smaller than the bore of the ring, thereby leaving $\frac{3}{16}$ in. space *B* between these two parts. This space is left for the steam to press or expand the piston rings. The steam for this purpose is admitted through a dozen small holes drilled in the follower plate on a circle the same size as the inside of the piston ring.

The question arises as to whether or not these rings will not bind so tightly as to score the cylinder, or to produce so much friction as to cause an excessive amount of oil to be used.

Mason City, Iowa. R. E. SKON.

QUESTIONS BEFORE THE HOUSE

Worthington Rotary Air Pump

Referring to the article by W. Vincent Treeby in your issue of July 22, 1913, we desire to emphasize most emphatically that this hydraulic vacuum pump is not an ejector, although sometimes carelessly so described—doubtless on account of confusion in the writer's mind because of the similarity in form to the ejector. The patent application was made and the patent granted upon this apparatus as a "vacuum pump," and its operation is clearly that of a pump.

While it is impossible for any obstruction to enter the rotor in such a way as to stop its rotation, it is possible by removing the oil cup mounted upon the nozzle head, to secure this shaft and to prevent its rotation, and by doing so, convert the apparatus into a type of ejector, which, however, becomes very inefficient.

It goes without saying that an ejector with fixed throat could be designed which would replace the jet-transforming wheel, but this would be a very different apparatus and would be lacking in the important features of the Worthington hydraulic vacuum pump.

This form of pump is superior in that it uses a simple centrifugal pump and a simple vacuum pump, instead of the complicated pump with many passages ordinarily used for this work. It is possible to place the vacuum pump right at the condenser if so desired. None of the rotors has shown any wear whatever, where the usual type requires constant oversight and replacement. The Worthington pump has a fair range in capacity and is less affected in its operation by air than any of the other types, while its thermal efficiency and its efficiency as an air compressor based upon isothermal compression, practically agree with the best pumps of this type.

GEO. J. FORAN.
HENRY R. WORTHINGTON.

New York City.

Algae in Water

In the July 1 issue, D. M. Liddell refers to the use of copper sulphate to kill algæ in water and to the probable damage to boilers by copper-sulphate-treated water.

I have had considerable experience with the copper-sulphate treatment of water for eradicating algæ for the past 10 years. We have a private reservoir of about 4,000,000 gallons capacity and have considerable trouble with algæ at times. It used to be so bad that the water stained finished cloth and gave it a rotten-fish smell; for drinking purposes it was no use at all as the smell would make one sick; in the boilers, the organic matter present would cause bad foaming. In 1904, having learned that a department of the Federal Government was experimenting with the use of bluestone as a purifier of water, we obtained all the information necessary for this treatment given in Bulletin No. 64 of the Bureau of Plant Industry, U. S. Department of Agriculture, issued May, 1904, and have used this method with success every year since.

The quantity of copper sulphate required depends on the germs of algæ present in the water, as some germs succumb quicker than others. The most common blue-green algæ, Anabæna *circ.* will all be killed by a solution of 1 in 1,000,000. Anabæna *flos-aqua* succumbs to 1 in 3,000,000, Uroglena, another common type, take 1 in 2,500,000, and the Spirogyra take a solution of 1 in 75,000 to kill them all; the Diatoms generally require a concentration of about 1 in 200,000.

However, it is not necessary to kill all the algæ, and a solution of 1 in 1,000,000 is strong enough to kill all the commoner types and prevent the growth of some of the other types.

For the success of the treatment the copper should be precipitated in the colloidal form, and if the water contains no alkaline salts, or is on the acid side, it will be necessary to add some lime to the water after the copper treatment to cause precipitation of the copper. As a general thing, however, natural waters contain enough lime or magnesia in solution to slowly precipitate the copper and neutralize the sulphuric acid.

The strength of the solution is not anywhere near the danger point of potability, as a man would have to get away with 50 quarts of water a day to produce any ill effects from the chemicals used.

As to the effect on boilers; a 100-hp. boiler working 12 hours a day and using 42,000 lb. of water in that time with a solution of copper sulphate of 1 in 1,000,000 would get 0.042 lb. of copper sulphate into the boiler, or 19 grams; this quantity of copper sulphate would do very little harm, especially as it can easily be neutralized by an equal quantity of soda ash which would precipitate the copper as a mixture of copper carbonate and copper hydrate and the acid would combine with the sodium, forming sodium sulphate, a neutral salt.

However, even if the solution in the reservoir is as strong as 1 in 1,000,000, the water delivered by the piping system will not carry anywhere near that amount of copper sulphate as the greater part of the salt is neutralized and precipitated in the reservoir itself.

When the algæ are killed by the copper, the vegetable matter coagulates and falls to the bottom, carrying most of the copper with it, and three or four days after the treatment, a very delicate chemical test is necessary to find even a trace of copper in the service water.

In our reservoir we used 60 lb. of copper sulphate the first year in one dose and 150 lb. the second year in two treatments. We have used about 100 lb. each year since, but have not found it to be needed this year so far. We have never had any trouble from copper poisoning or any complaints of ill effects and not the slightest sign of copper deposits or corrosion in the boilers or piping. We have always used some form of soda in our boiler feed; usually Tri-Sodium Phosphate, purchased in the open market.

This treatment generally kills most of the bottom-feeding fish, such as suckers, bull heads and ells, and it is necessary to keep a man at the reservoir cleaning up for a few days after a treatment. These fish eat the dead algæ that falls to the bottom and thus get the most of the copper. No trout, pickerel or bass will be killed with a solution as weak as 1 in 1,000,000 and game fish seem to be immune to this quantity. Mr. Liddell says that the copper will be injurious to vegetation if the water is used for irrigation, but this depends on the strength of the solution and the state of plant growth. Copper sulphate was first used to kill algæ in water-cress beds and thus save the young plants from suffocation by the algæ. Copper solutions will, however, prevent the germination of seeds and the growth of young seedlings in as small a concentration as 1 in 20,000,000.

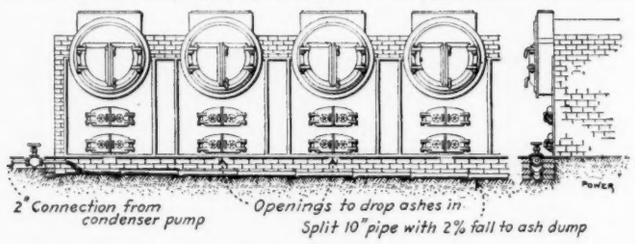
BENJAMIN S. HANSON.

Broad Brook, Conn.

Uplift the Boiler Room

The editorial upon the above subject in the June 24 issue was timely. In many boiler rooms of moderate size the firemen are practically doomed to continue the disagreeable job of wheeling out hot ashes, owing to the cost involved in the installation of an ash-handling system.

Possibly an account of how the difficulty was overcome at one plant may help out some brother engineer, who has



SEWER FOR CONVEYING ASHES

similar conditions to contend with. An ash-handling system was proposed for the plant in question, but when the management heard what the equipment would cost, there was a prompt command for all hands to forget it.

The chief engineer, however, was not easily discouraged, and he began to look around to see if there was not some kind of home-made system that could be installed without the management being any the wiser. Plenty of water was available, and the boiler room was so located that there was a low, swampy place on one side, into which the ashes were dumped. The chief got a few lengths of cast-iron pipe, about 10 in. in diameter, that had been left over from another job. He had these pieces split open lengthwise, and used them to form the bottom of a trough, which was laid in front of the boilers, as shown in sectional view. The sides of this trough were made of brick and iron floor plates were used to cover the top of the trough. These floor plates had rectangular openings in them, opposite the ashpit doors, and light covers were used to close the openings in the floor plates when the system was not in use. The covers were provided with rings so that they could be easily removed with a poker.

The bottom of the trough was laid with a fall of about 2 feet in 100 ft. and the discharge end of the trough was located at the ash dump. At the upper end of the trough, there was placed a 2-in. pipe connection from the condenser pump, and when it was desired to clean fires, the valve on this pipe was opened and a stream of water was allowed to flow through the trough, while the ashes and clinker were being raked into it.

The ability of a 2-in. stream of water to move objects in a trough of the size given, and with the fall stated above, is remarkable. No clinker that could easily get through the openings in the floor plates (which were 6x18 in. in size) seemed to have the least trouble about being carried out, and pieces of brick could be dropped in while ashes were being drawn, and they would be carried along the same as the clinker.

The accompanying figure will show how the trough was arranged, and anyone who has similar conditions in regard to a place to deposit ashes will do well to install this system. The water used during operation is considerable, but it is used only at infrequent intervals and during short periods of time, and the amount used per day is really small. The ashes do not tend to collect at the discharge end of the trough, as might be expected, but will spread over a wide area, particularly if the ground slopes down from the discharge end of the trough.

J. E. TERMAN.

Hartford, Conn.

Making a Flue-Gas Analysis

After reading over the Engineers' Study Course article on "Making a Flue-Gas Analysis" in the July 8 number I would like to suggest a second method of obtaining the zero reading in the burette.

Pump in a sample of gas, close the three-way cock and remove the pump in the usual way. Raise the leveling bottle until the gas in the burette is under a slight pressure and open the three-way cock to the air. Close the three-way cock when the water is within a half inch or so of the zero line. This may be done quickly as long as care is taken that the water does not rise above the zero line.

Now raise the leveling bottle and compress the gas until the water level is exactly on the zero line and pinch the rubber-hose connection either with the pinch cock, or, as will be found easier, with the fingers. Place the leveling bottle on top of the apparatus or any place, as its position will have no effect on the water level as long as the hose connection is pinched. Open the three-way cock to the air for an instant and close it again.

Finally release the pinch cock and check up the zero reading by holding the water level in the leveling bottle opposite the water level in the burette.

I have used this method for a long time and it is seldom that the zero reading will vary more than 0.1 of 1 per cent. Such a variation may be subtracted or added to the per cent. of CO_2 obtained in the subsequent absorption and the error will become negligible. I can strongly recommend the above method, not only for accuracy and reliability but also for ease and speed of performance.

LOREN L. HEBBERD.

Milwaukee, Wis.

INQUIRIES OF GENERAL INTEREST

Conical Pistons—Why are the pistons in some engines made conical in shape?

W. C.

To reduce the weight for a given required strength.

Boiler Joint—In a double-strap butt joint why is the wide strap inside and the narrow strap outside?

W. C.

The narrow strap is placed on the outside of the boiler as the pitch of the rivets along the edge of the narrow strap is small enough for the calking pitch.

Boiler Safety Factors—Why should a larger factor of safety be allowed for stays and staybolts than for the shell of a tubular boiler?

W. C.

Because they cannot be inspected so minutely and the material is more likely to contain hidden flaws.

Metal Melting Points—What are the melting points of babbit and zinc?

A. C. H.

Zinc melts at 786 deg. F. Commercial babbit metal is made in a variety of proportions of copper, antimony, zinc and frequently lead with an average melting point of about 1000 deg. F.

Rate of Spring Flow—What is the best way to measure, approximately at least, the rate of flow of water from a spring?

W. K. G.

The best and most convenient way is to measure the discharge by a weir. A complete description of the construction and use of weirs is given in "Power," Dec. 28, 1909, pages 1090-1094.

Space Over Bridge Wall—How large should be the cross-sectional area of the space between the under side of a horizontal tubular boiler and the bridge wall?

W. C.

Never less than the cross-sectional area of the tubes to insure full draft area, but it may be anything larger if the bridge wall is high enough to prevent the fire from being pushed off the grate.

Safer Boiler—For the same size and capacity and to carry the same pressure, which is the safer a vertical or a horizontal fire-tube boiler?

W. C.

Vertical boilers are more likely to fail in the tube sheets than horizontal tubular boilers and are likely to become clogged and to burn in their water legs. In these two respects the horizontal boiler is safer.

Boiler Horsepower—How is the horsepower of a boiler determined by test?

W. C.

The quantity of water fed per hour and the pressure at which it is generated into dry steam are ascertained. The feed water should be weighed, and the equivalent evaporation in pounds from and at 212 deg. F. per hour divided by 34½ would be the performance in boiler horsepower.

Bearing Boxes—Why do some engines have bronze boxes in the crosshead end and babbitt boxes in the crankpin end of the connecting rod? Is it not better to have babbitt boxes in both ends?

W. C.

Crosshead boxes are not so frequently babbitted as crankpin boxes as the former do not require renewing as frequently as the latter, the wear being less on the crosshead pin.

Expanding Boiler Tubes—When expanding tubes in return-tubular boilers, how much pressure, if any, should there be on the boiler and should the plate be hot or cold for best results?

M. W. C.

The tubes of return tubular boilers should be expanded with boiler empty and cold, otherwise the tubes will contract away from the tube sheets and leak when they become cooled down.

Four Valve vs. D-Slide Valve—In respect to valve setting, what advantage has a four-valve engine over a D-slide valve engine?

G. A. M.

A four-valve engine has the advantage that admission and exhaust are controlled independently for each end of the steam cylinder, whereas, in a D-slide valve engine, the valve being in one piece or assemblage of pieces whose relative position is fixed, setting the valve for regulating either admission or exhaust on either end of the cylinder, affects all other distribution.

Parabolic Governor—What is the difference between a parabolic and an ordinary governor?

W. C.

In the ordinary governor the balls swing on circular arcs; in the parabolic governor they are constrained to follow parabolic arcs. The former governor is not isochronous, i.e., does not give absolutely uniform speed at all loads. The parabolic governor, by virtue of its construction, is satisfied at only one certain speed, and, regardless of load, assumes a position which maintains that speed. The parabolic governor is not built because its refinement of regulation over the ordinary governor is not commercially warranted.

Laying Out Steam Pipe—What precautions should be taken in running a steam main from a battery of boilers? Where and how should the main stop valve be placed?

W. C.

Precautions should be taken to avoid strains on the pipe and fittings from expansion and contraction, to hang and support the pipe so that it may have perfect freedom in expanding and contracting, and to provide proper pitch and facilities for draining the pipe of water of condensation. The main stop valve should be as near as possible to the main boiler header, and, if a globe valve, should be placed with the spindle horizontal with the valve closing against the source of pressure.

Cause of Leaky Tubes—Would closing the damper in the stack cause the tubes in a boiler to leak? The boilers are fired with kiln-dried sawdust and shavings through self-feeding spouts from a blower system.

M. W. C.

Boiler tubes leak from expanding and contracting unequally with the tube sheet and the more frequently the temperature is raised and lowered the sooner will the tubes leak at their joint with the tube sheet. In so far as the use of a damper may be the cause of fluctuations in the temperature of gases which come in contact with the tube ends, the presence of the damper may be charged with causing leakage of the tubes.

Boiler Equalizers—Where three supports are necessary on each side of a horizontal boiler, why should equalizers be used? What is an equalizer?

W. C.

Equalizers prevent an undue portion of the load from coming on any one or two of the supports. Three supporting brackets on a side would not be equally loaded if one bracket support settled down lower, or, from expansion of the supporting walls, was raised higher than the relative heights of the brackets on the boiler. An equalizer is like a whiffle tree supported at its center of length and having suspending rods (like traces) for suspending a boiler bracket from each end in the same manner that equalizers are used on the sides of a locomotive for suspending the side frame by levers, which are supported on the axle boxes.

ENGINEERS' STUDY COURSE

Evaporation

Solution of Chimney Problem

The draft required for the breeching is,

$$(50 \times 0.001) + (2 \times 0.05) = 0.15 \text{ in.}$$

which, added to the draft required by the boilers, makes a total of

$$0.15 + 0.4 = 0.55 \text{ in.}$$

for breeching and boilers. The rated boiler horsepower of the installation is

$$8 \times 500 = 4000$$

and as this will be subject to a 25 per cent. overload we must provide a chimney for

$$4000 \times 1.25 = 5000 \text{ hp.}$$

As it is estimated that 4 lb. of coal will be required to develop one boiler horsepower, the total maximum consumption will be

$$5000 \times 4 = 20{,}000 \text{ lb. per hr.}$$

The total grate area is

$$83 \times 8 = 664 \text{ sq.ft.}$$

Hence, the pounds of coal burned per square foot of grate per hour are

$$20{,}000 \div 664 = 30.12$$

And the draft required for the combustion of bituminous slack at the rate of 30 lb. per square foot of grate per hour is, according to the table given last week, 0.4 in. of water. Then, the total available draft necessary is

$$0.55 + 0.4 = 0.95$$

Applying this figure in the formula for estimating the height of chimney we have

$$H = \frac{1.25 \times 0.95}{0.52 \times 13.57 \left(\frac{1}{520} - \frac{1}{1010}\right)} = 180.47 \text{ ft.}$$

as the required height of chimney above the grates.

Employing the formula for figuring the necessary cross-sectional area of the chimney we have

$$E = \frac{20{,}000}{16.65 \sqrt{180.47}} = 89.44 \text{ sq.ft.}$$

which would mean a chimney 10 ft. 8 in. in diameter.

Water

Water is an indispensable commodity in almost every phase of life and industry. Agriculture would be an impossibility without it. The human being himself would not amount to much if it were not for water, for his substance is more than half made up of that commonplace fluid. A modern power plant, no matter of what type, could not be operated if water were not available.

Then, in view of the all-importance of this fluid, it would seem desirable for everyone to know something about its character and habits. As a complete treatment of the subject would be too extensive for the limited space permitted for its discussion here, and as the great majority of the readers of this department are concerned mainly with the operation of steam plants, only those characteristics of water will be taken up that are prominent in the steam plant.

Water is composed of the two gases, hydrogen and oxygen combined chemically in the proportion by volume of two parts of hydrogen and one part of oxygen. The chemical formula is H_2O, which should be familiar to all who have followed this series from the start, as water is the product formed by the combustion of the hydrogen found in such fuels as coal, oil, gas, etc. The reaction which takes place was explained in the first and third lectures on combustion, April 22 and May 6 issues, respectively.

Water in the liquid state and at 62 deg. F. weighs 62.355 lb. per cu.ft. Its weight or volume varies with changes in temperature. At 212 deg. F. the weight per cubic foot is 59.76 lb. and at 32 deg., 62.418 lb. Because of this difference in weight at different temperatures, circulation can be established by applying heat. The water in the bottom of a system expands or becomes lighter when heated and rises or is forced up by the heavier cold water above, which flows down and takes its place and in turn is heated and rises.

Boiling Temperature

If sufficient heat is applied to water in its liquid state it will commence to boil. This boiling results in some of the water being converted into a vapor which is called steam, and if the boiling is continued all the liquid will be changed into steam. The temperature at which water will boil depends upon its purity and the pressure to which it is subjected. Pure water in an open vessel subjected to the normal atmospheric pressure at sea level of 14.7 lb. per sq.in. boils at 212 deg. F. The common impurities found in water in its natural states tend to raise the boiling temperature. Thus, sea water which contains salt as its principal impurity will not boil under atmospheric pressure until the temperature reaches 213 deg. or a little higher, depending on the exact percentage of the impurities contained. The influence of impurities on the boiling temperature is very slight (compared with the influence of pressure), and as the water used in steam boilers never contains but a comparatively small quantity of impurities, this influence is customarily neglected in steam-plant work.

For every pressure there is a fixed temperature at which water boils. The higher the pressure the higher the boiling point. If the temperature of boiling water or of the steam being formed therefrom is known, the pressure can be ascertained without a gage, simply by referring to a table of temperatures and pressures, as these always correspond. In a like manner, if the pressure is known the temperature can be determined without a thermometer.

The same principles apply when water freezes to form ice. Pure water at the normal atmospheric pressure at sea level (14.7 lb. per sq.in.) freezes at 32 deg. F. Impurities tend to lower the freezing point. Thus, ordi-

nary sea water freezes at about 27 deg. The higher the pressure the lower the freezing point.

When water is undergoing the process of boiling the steam formed has the same pressure and temperature as the boiling water from which it is being formed or evaporated. Such steam is known as saturated steam.

Now, if heat is applied to the steam itself and the containing apparatus is arranged in such a manner that the steam is not in close contact with water and hence cannot impart this extra heat to the water to form more steam, the temperature and pressure will both tend to rise. But the new temperature of the steam will not correspond with the boiling temperature of water at a pressure equal to the new pressure of the steam. The temperature will be higher. Such steam is called superheated steam.

To sum up, then, the boiling point of water depends upon the pressure; the boiling temperature is fixed and unchangeable for any given pressure. Saturated steam is steam that has the same temperature as boiling water under equal pressure. Superheated steam is steam that has a higher temperature than boiling water under the same pressure.

Saturated steam may be dry or wet. Dry saturated steam is steam that has been thoroughly evaporated and does not carry any drops, globules, or particles whatsoever of liquid water in the form of a spray or mist. A clearer and more definite explanation of the difference between dry and wet steam will be given further on.

Evaporation

Ebullition is the name sometimes given to the process of boiling or steam generation; a commoner name is evaporation. We speak of the evaporation per pound of coal, equivalent evaporation, etc. Then, there is another term often used: vaporization, the process of changing from a liquid to a vapor, that is, of changing from liquid water to steam. Although the last two terms really mean the same thing, custom has established a slight distinction. Evaporation has come to mean the whole process of making steam, starting with the warming up of the feed water to the boiling temperature and including the actual conversion of the water into steam, while vaporization has come to be considered simply the actual conversion from water at the boiling point into steam at the same temperature and pressure.

Latent Heat

When we apply heat to a body we instinctively think of an accompanying rise in temperature. For instance, if we apply heat to a piece of iron we know that the temperature of the iron quickly goes up. When we apply heat to water, say, at 60 deg., the water grows warmer—its temperature rises. The water will continue to get hotter, the more heat we add, until the boiling point is reached. If the water is in an open vessel and at sea level this point will be at the 212 deg. mark. Now, right here a strange thing will occur. The water will fail to get any hotter. No matter how much heat we apply, no matter how hard we force the fire or how high we turn the gas burner, whichever it happens to be, the thermometer will stick at 212 deg. If you doubt this, try the experiment with a pan of water and thermometer and convince yourself.

The water will cease getting hotter, but at the same time something else will happen. The instant the boiling point is reached ebullition—the process of steam generation—will set in. The question naturally arises: If the temperature cannot be increased by applying more heat, what becomes of this extra heat? It is used in converting the liquid water into steam. As soon as the heat is shut off the boiling or steam-making will cease, proving that heat is required to convert the water from the liquid into the vaporous state. The more heat we apply the more rapid will be the rate of steam generation.

It requires 970.4 B.t.u. to change 1 lb. of water at atmospheric pressure and a temperature of 212 deg. into steam at the same temperature. Just why so much heat is used up or absorbed without causing a rise in temperature when water is broken up into steam I will not attempt to explain here. The only really important thing to know is that such is the case. The heat thus absorbed is called latent heat of vaporization or the latent heat of steam. The term latent means hidden or secret. Hence, the latent heat of steam is the heat that is taken up and hidden by the water when it changes from its liquid to its vaporous state. We consider the heat as being latent or hidden because we can see no evidence of its having gone into the steam as far as the thermometer can tell us.

When steam condenses the heat transfer is the other way. If a pound of steam at atmospheric pressure were injected into a tank containing 99 lb. of water at, say, 60 deg., so that all the steam condensed back into water, the temperature of the resulting 100 lb. of water would be 71.2 deg., showing a rise of 11.2 deg. for the original 99 lb. of water.

The temperature of steam at atmospheric pressure is 212 deg. Hence, the drop in temperature was only

$$212 - 71.2 = 140.8 \ deg.$$

But the 99 lb. of water rose 11.2 deg., showing that

$$99 \times 11.2 = 1108.8 \ B.t.u.$$

were imparted to it. (One B.t.u. being the amount of heat required to raise the temperature of 1 lb. of water 1 deg.)

If the steam had been condensed before it was injected into the 99 lb. of water so that it went in as a liquid at 212 deg. instead of a vapor at 212 deg., the rise in temperature of the 99 lb. would be only 1.52 deg. because the pound of condensed steam or water at 212 had only

$$212 - 60 = 152 \ B.t.u.$$

more in it than a pound of the cooler water.

Some, who are just beginning the study of evaporation and steam, may experience a little difficulty in realizing that steam has weight, and, hence, may be slightly confused when they come in contact with such terms as pounds of steam, etc. This confusion is all the more likely because the pressure is also spoken of in terms of pounds.

In an earlier lesson (April 22 issue) it was shown that a gas has weight, and in the same manner it could easily be demonstrated that steam has weight. In fact, the weight of steam can be ascertained more easily than the weight of a gas; all that is necessary is to condense the steam and weigh the resulting water. In referring to a quantity or weight of steam the word "of" is employed. Thus, we say, 9 lb. *of* steam evaporated per pound of coal. Which means that the combustion of a

pound of coal has caused the evaporation of 9 lb. of water, resulting in the generation of 9 lb. of steam.

In referring to pressure we use the word "at." Thus, steam *at* 150 lb. Which means steam which causes or possesses a pressure of 150 lb. on each square inch of the surface confining it.

Autogenous Boiler Welding

It has been the editor's privilege to spend some pleasant hours with Theodore Kautny, the leading authority of the world upon autogenous welding. Under his direction numerous classes have been established in the industrial schools for teaching the process. He is the author of several standard works upon this subject, and finds time in the intervals of an extensive consulting practice to direct the publication of *Autogene Metallbearbeitung,* a monthly journal devoted to this specialty. He has consented to furnish some articles to future issues of POWER showing how this process is employed for engine and boiler repairs and in improved methods of manufacture of power-plant apparatus.

In reply to an inquiry as to the possibility of the replacement of the riveted joint by the autogenous weld in steam boilers, Mr. Kautny said that there are promising possibilities in that direction, but that he is exerting his influence to withhold any serious attempt in that direction until a means has been found of proving the soundness of the weld. To this end a prize of 1500 marks has been offered for the best suggestion of a method of testing, which offer has brought out 26 replies. These are to be referred to a committee consisting of Prof. Dr. Schlesinger, of the Technical High School, Charlottenburg; Geheimrat Prof. Dr. Ing. Wüst, of the Metallurgical Institute, Aachen; Prof. Baumann, of the Royal Technical High School, Stuttgart; Ing. Herrn. Richter, of the Technical State Schools of Hamburg; Overingenieure K. Schröder, of the Huldschinskywork at Gleiwitz (Silesia) and Mr. Theodore Kautny himself, for the award of the prize. The suggested methods include heat and electrical conductivity, sound, vibration, etc.

The autogenous weld is already extensively employed to join nozzles onto large work, like receivers, etc., and when the joint is properly made it is as strong as the metal itself. It only remains to be able to check the workmanship.

Mr. Kautny has also an ingenious demonstration of the effect of changes of temperature and stress in producing distortion and strain in riveted joints. This consists in plotting the expansion of the various parts under differences of temperature and making some 500 drawings showing the successive positions. When these are photographed and run through a kineomatagraph the movement of the sheets and rivets will be visually reproduced. As an instance of the effort to avoid the riveted joint, Krupp is making some drums for water-tube boilers for the Russian Government about 10 ft. in length and between 2 and 3 ft. in diameter, by boring out large forgings, leaving a cylinder or shell of something over an inch thick.

Hard Coal Production—Anthracite ecoal shipments in the first seven months of 1913 were over 40,000,000 tons. This year's production of anthracite coal will probably exceed the high record of 1911, which was 69,954,299 tons, and pass the 70,000,000-ton mark.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Out Seattle way, if the street merchant would continue to roast peanuts, he must qualify as an engineer—a goober engineer, a steam peanuter. We already have a few "peanut" engineers who roast— What we started to say was, Boiler Inspector Albert Johnson declares that the peanut roaster is dangerous, and the operators must be licensed. Men have been killed through careless handling of the deadly little steam boiler. Sure, license everybody who makes steam; raise the standard from peanuts to power house. Then sic the noise-prevention committee onto the peanut engineer's blooming whistle.

Shank to get 45 bee stings—Headline.

About half a sting will ordinarily more than satisfy the average shank. This particular Shank is Lew Shank, mayor of Indianapolis. Lew has "a tech ob de mis'ry," and hopes by this means to effect a cure.

We should worry about the coal supply and get a cinder in our eye! A man named Wade, from Philadelphia, has waded to some purpose, he thinks. Wade claims he can combine the water gases with oil, expand and bake them, and thus have a fuel. About a column of newspaper rough stuff tries to explain his process and apparatus—but what's the use, you wouldn't believe it.

Like all papers with a large correspondence, "Power" occasionally receives some queer spelling, but we raise our Panama to New York's Street Cleaning Commissioner: Here's his list of spellings of "garbage:" "Grabbrage, carbage, garbages, garbege, gabbage, cabbage, garbagge, garbach, gobbage, garbbes, garbadge, garbeg, garbig, garbish, garbige, gurbabe, garbrage, cabage, cabhage, carbbage, garvages, gabbade, carbig, carrbage, garrebge, gabbatche, carribag, garbitsch, garbich, garbetz, gorbige, gerbag, garbager, garbet, gorbage, garrabage, gobers, garbabege, garberg, garbedg, carbiche, gerban, garbetch, garbegge, fabage, grarbage, gabes, garbit, garbush, carbag." They've bin havin' a swill toime, says Cassidy. A list of th' odors would fill a book.

It's been said that the English dearly love a title. However true this may be, and at the risk of precipitating a war between the two countries, we have been told that in Germany lives a professor who gets mad enough to sue the paper which neglects to give his full title when mentioning his name. To escape a libel suit, his last name is omitted (it has only four letters, anyhow, and will never be missed). Here's the title: Herr Geheimer Regierungsrath, Professor Doctor-Ingenieur Doktor Friedrich ———. Over here, you'd have to get good and mad before you could make even a fair stab at it.

Twenty pounds weight may now be sent through the mails. Keep this in mind when planning your trip to the N. A. S. E. convention at Springfield. This is a friendly tip to the souvenir gatherer. He may send his spoils home by the parcels post. Of course, if he has collected over 20 lb., and it's going to crowd his luggage, it would be safer to hire a box car.

Glory be, Jawn, here's another wan av thim newspaper cylinder-head bust-ups. This toime it do be in th' Noo Yawk Criminynal Coorts buildin'. Th' cub who wrote it up declares that an outrajus flood, which engulfed Rosie M'Carty, the butiful tillyphone operatress, wuz caused by "th' blowin' out av a wather-pipe cylinder head." An' sez he, brave Rosie sthuck to her post; she niver moinded th' slathers of plaster an' fallin' debree which threatened to engulf her. An' whin the crool flood had subsided, th' little darlint sthill sthuck, 'till relaysed be th' rescuin' populace. True for you, Jawn, they niver found th' devastatin' wather-poipe cylinder head that caused all th' ructions. 'Twould sarve that rayporter chap roight if they made him luk fer it—an' kep' him on th' job till he found it!

Michigan N. A. S. E. Convention

The twelfth annual convention of the Michigan State Association of the National Association of Stationary Engineers was convened in Grand Rapids, on Aug. 6, with Press Hall as the meeting place and exhibit building. Bert Wells, of the local committee, presided at the preliminary ceremonies on Wednesday morning in place of Chairman Chas. W. Merritt, who was unavoidably prevented from being present by serious illness in his family. The Rev. J. R. T. Husted pronounced the invocation and in the absence of Mayor Geo. E. Ellis, also delivered the address of welcome, to which National Secretary Fred W. Raven responded. Lee H. Bierce, representing the Grand Rapids Association of Commerce, gave an interesting address, setting forth the opportunities existing in the city. John W. Lane, editor of the "National Engineer," responded.

State President W. M. Gormley was then introduced and the various committees were appointed. In the absence of National President John F. McGrath, State President Gormley officially opened the exhibit hall and A. T. Arens, of Jenkins Bros., gave a brief address on behalf of the exhibitors.

At the Thursday morning session the matter of a state license law was taken up and the educational prizes were awarded. In its report the license-law committee described some of the obstacles and difficulties encountered by it in attempting to have a bill put through by the state legislature. Continued effort toward the passage of the bill is to be made this year. The first educational prize, $20 in gold, donated by J. D. Swartwout, of Saginaw, was won by Arthur M. Adams, of Kalamazoo. The second prize, $10 in gold, presented by the Standard Oil Co., was awarded to G. C. Wetherly, of Saginaw. M. A. Knight, Kalamazoo, won the third prize, a copy of Kent's Mechanical Engineers' Pocket-book, given by Aaron Miller, and W. W. Clark, Saginaw, took the fourth, a slide rule, presented by the S. P. Conklin Co. These prizes were awarded for the best answers to a set of questions issued by the educational committee.

W. A. Sperry, operating chemist of Grand Rapids' new filtration plant, gave a lecture on the principles and features of the plant. His talk was followed by an address by G. G. Whitworth, treasurer of the Berkey & Gay Furniture Co., on "The Engineer from the Manufacturer's Viewpoint." In the course of his remarks the speaker declared that there was a tendency on the part of people generally to consider a genius as a fellow who is divinely gifted. The true cause of genius, however, is inclination for hard work, intense study along the line on which one aims to progress. Luck is governed largely by personal application.

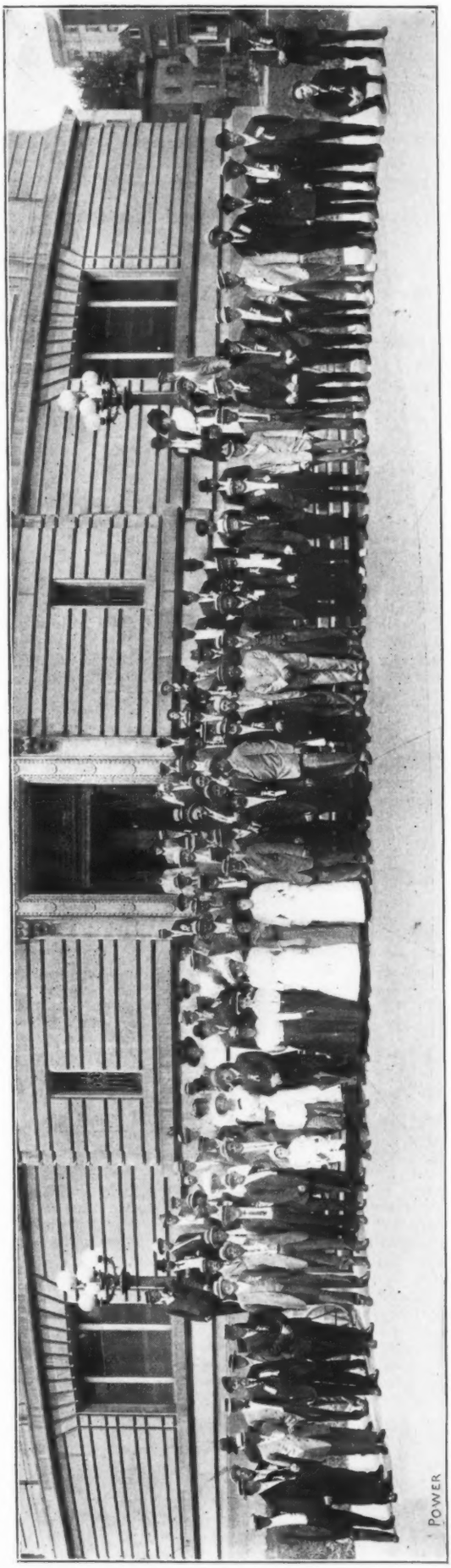
In responding, F. A. Wells, chief engineer of the Michigan Leather Co., outlined the purpose of the N. A. S. E. and declared that one of the important objects of the organization was to bring the manufacturer and engineer into closer touch.

At the annual election, which was held on Friday morning, these officers were chosen: A. W. Miller, Detroit, president; John Andrews, Pontiac, vice-president; E. C. Smith, Kalamazoo, reëlected secretary; H. T. Bagley, Owosso, treasurer; G. T. Maloney, Owosso, conductor; Otto Mauthe, Muskegon, doorkeeper; Fred Tisch, Flint, trustee; H. A. Pierce, Kalamazoo, state deputy. Muskegon was chosen as the place for the next annual state convention. Past National President C. W. Naylor, National Secretary Fred Raven, and John Lane, editor of the "National Engineer," made brief appropriate addresses after the election.

Chief among the entertainment features of the convention program was a baseball game and picnic on Thursday afternoon and evening at Ramona Park, an amusement resort near the city. The game was won handily by the engineers, who made a score of 10 runs against the 4 by the supply men. On Wednesday afternoon an auto ride was provided for the lady guests and on Thursday morning they made a shopping trip to the principal downtown stores. On Wednesday evening an informal entertainment consisting largely of musical numbers by talented representatives of the supply houses was given in the exhibit hall and on Friday evening the Grand Rapids Evening Press Newsboy Band gave a concert in the same place. On Friday afternoon a visit was made to the new filtration plant and the city water works.

Over 40 booths in the exhibit hall were occupied by the displays of the following concerns:

Falls Machine Co.
Anchor Packing Co.
Crandall Packing Co.
Hawkeye Compound Co.
United States Graphite Co.
Standard Oil Co.
Grand Rapids Supply Co.
Garlock Packing Co.
Grand-Rapids-Muskegon Power Co.
Arrow Boiler Compound Co.
Crane Co.
Aaron Miller.
Diamond Power Specialty Co.
Raniville Co.
White Star Refining Co.



GROUP AT MICHIGAN STATE N. A. S. E. CONVENTION, GRAND RAPIDS, AUG. 6, 7 AND 8

Lagonda Manufacturing Co.
Harrison Safety Boiler Works.
Viscosity Oil Co.
Jenkins Bros.
Greene, Tweed & Co.
Dearborn Chemical Co.
V. D. Anderson Co.
Lunkenheimer Co.
Underfeed Stoker Co. of America.
"Power."
Barclay, Ayers & Bertsch Co.
Kenneth Anderson Co.
J. I. Wernette.
Wickes Boiler Co.
Lake Erie Compound Co.
Richards Wilson Pipe Covering Co.
International Correspondence Schools.
Buckeye Chemical Co.
Bousman Mfg. Co.
Wm. Powell Co.
Leitelt Iron Works.
Central Boiler & Supply Co.
Nelson Valve Co.
Hills-McCanna Co.
Cahall Boiler Co.
Breen & Halladay Fuel Co.
Albany Lubricating Co.
Fairbanks Co.
H. W. Johns-Manville Co.
C. A. Dunham Co.

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CORRECTION—On page 255 of the Aug. 19 issue, Figs. 2 and 3 are in error in that the bridge-wall is shown extending up to the bottom of the tubes. With the horizontal baffles it should, of course, be considerably lower to allow a passage for the gases.

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Graft in Chicago Smoke Department

Nine of the deputy smoke inspectors for the City of Chicago have been on trial before the Civil Service Commission, charged with petty graft, favoritism, false reporting, insubordination and loafing. Eight of the nine were promptly convicted and ordered discharged from the service.

Chief Smoke Inspector Osborn Monnett has had private detectives at work on the movements of his subordinates for several months past and according to the testimony given in the trial a fine record of contemptibly small grafting has been unearthed. It was brought out that some of the large manufacturing concerns in the city whose chimneys were smoking offensively were in the habit of giving presents and even sums of money to the deputy inspectors to win freedom from unfavorable reports. Such commodities as ham, bacon, shoes, neckties, etc., were on the list of "gifts" said to be received regularly by the accused men. The agents of certain coal companies are alleged to have claimed that they have a "pull" with the smoke-inspection department and that if coal was purchased from them no trouble would be caused by the department if the customer's chimney smoked.

An engineer in charge of a plant in an office building, owned by a large railroad entering the city, testified that the accused smoke inspectors were in the habit of foregathering in his plant and whiling away the weary hours of duty by playing cards and eating repasts generously provided by the packing and manufacturing companies of guilty conscience and temptingly cooked and served by the aforesaid engineer. The selection of this plant as the rendezvous for members of the deputy inspectors' "We-Should-Worry Club," was prompted by an official of the operating department. The inference is that through this little courtesy he won immunity for his company from prosecution for violation of the smoke ordinance by its locomotives.

❋

The International Congress of Refrigeration

Delegates are coming from forty-two countries to attend the Third International Congress of Refrigeration, of which President Wilson is patron, to be held in Chicago from Sept. 17 to Oct. 1. Secretary of Agriculture Houston is honorary president.

More than 5000 manufacturers, scientists, engineers, ice producers and dealers in all sorts of produce which depends on refrigeration to prevent the enormous waste which would otherwise result, will assemble for the congress. The foreign delegates will be mustered at New York where a committee will welcome them. A special train will transport the party to Washington, where they will be received in person by President Wilson and addressed by Mr. Houston. The trip to Chicago will be by special train.

The committee in charge of the congress announces daily executive sessions to be addressed by prominent personages, including Dr. Harvey W. Wiley, former chief of the United States Bureau of Chemistry; Dr. Alex. C. Humphreys, president of the Stevens Institute of Technology; Dr. S. W. Stratton and C. W. Waidner, of the Bureau of Standards, Washington, D. C.; W. C. Brown, president of the New York Central lines; C. W. Secrist, vice-president and general manager of the Pacific Fruit Express; J. M. Culp, vice-president of the Southern Railway; James R. Mann, congressman from Illinois; Professor E. Spencer Baldwin, Boston; Dr. H. E. Barnard, state food and drug commissioner of Indiana, and many others who are prominent in commercial, manufacturing and transportation lines.

Concurrent with the congress will be held an international refrigeration exposition. This is to be the first exposition of this nature ever held. The United States government will have a special exhibit. During the congress a banquet will be tendered to the foreign delegates, at which only cold-storage food-stuffs and beverages will be served.

NEW PUBLICATIONS

ENGINEERING TABLES AND DATA. By W. W. F. Pullen. The Scientific Publishing Co., Manchester, England. Limp cloth; 68 pages; 5½x8½ in.; 3 charts; 7 figures. Price, 1/6.

This work is a collection of tables and data for handy reference in the laboratory, the testing shop and in engineering educational work generally, consisting of tables of circular measure of angles, trigonometrical functions, common and hyperbolic logarithms, exponential and hyperbolic functions, conversion factors (Metric to English and English to Metric measures), water density, specific heat, etc., of various substances, tables relating to fuel and combustion; steam tables in Fahrenheit and Centigrade units; mean specific heat of superheated steam, 20 to 220 lb. absolute; charts of steam dryness for use with throttling calorimeter, of sulphur dioxide and of CO_2; mensuration of the principal geometrical figures employed in engineering computations and standard differential coefficients and differential equations.

The compiler states that steam tables have been prepared upon values obtained by recent experimenters; it is to be regretted, however, that they have been computed on the basis of the old British thermal unit in place of the unit more generally accepted by American engineers, viz.: $^1/_{180}$ of the heat required for raising a pound of water from 32 to 212 deg. F. The resulting differences are small enough to neglect for all practical purposes, but they are annoying and in some cases may be confusing to those accustomed to the more generally accepted American standard.

SOCIETY NOTES

On Sunday, Aug. 17, Local Union No. 68 of the International Union of Steam Engineers of Newark, N. J., held its annual outing at Donnelly's Grove, College Point, N. Y. A big percentage of the members and many friends of the organization enjoyed the day together.

Phoenix Association No. 24, N. A. S. E. of New York City held its 23d annual outing at Donnelly's Grove, College Point, N. Y., on Sunday, Aug. 17. There was the usual big attendance. A baseball game between the members of Phoenix and the "Bunch" was won by the latter, followed by a program of races. A hearty dinner wound up the day's fun.

More than twenty thousand people attended the outing and picnic of the Eccentric Firemen, Local union No. 56 of the International Brotherhood of Stationary Firemen of New York City at Celtic Park, Long Island City, on Sunday, Aug. 17. There was an elaborate program of popular out-door sports with handsome prizes to the winners. Dancing and other enjoyable pastimes were arranged for the ladies. International-President Timothy Healy was on hand to welcome the guests.

PERSONALS

H. C. Behr has resigned as consulting mechanical engineer in South Africa for the Consolidated Gold Fields of South Africa, Ltd., and will engage in professional work, specializing as consultant in the design, construction, operation and maintenance of the mechanical part of mining and metallurgical plants, with office at 233 Broadway, New York.

James D. Robertson, formerly sales manager for the Pittsburgh Valve, Foundry & Construction Co., has again assumed charge of the sales of this company, returning as second vice-president after two years' absence. Mr. Robertson in the meantime has successfully completed the organization, plant, and launching in business of the Warren Tool & Forge Co., of Warren, Ohio. He began his business career with Atwood & McCaffrey, and when that concern was absorbed by the Pittsburgh Valve, Foundry & Construction Co., he continued his services and up to the time of his withdrawal had completed his 21st year with the company.